POWER

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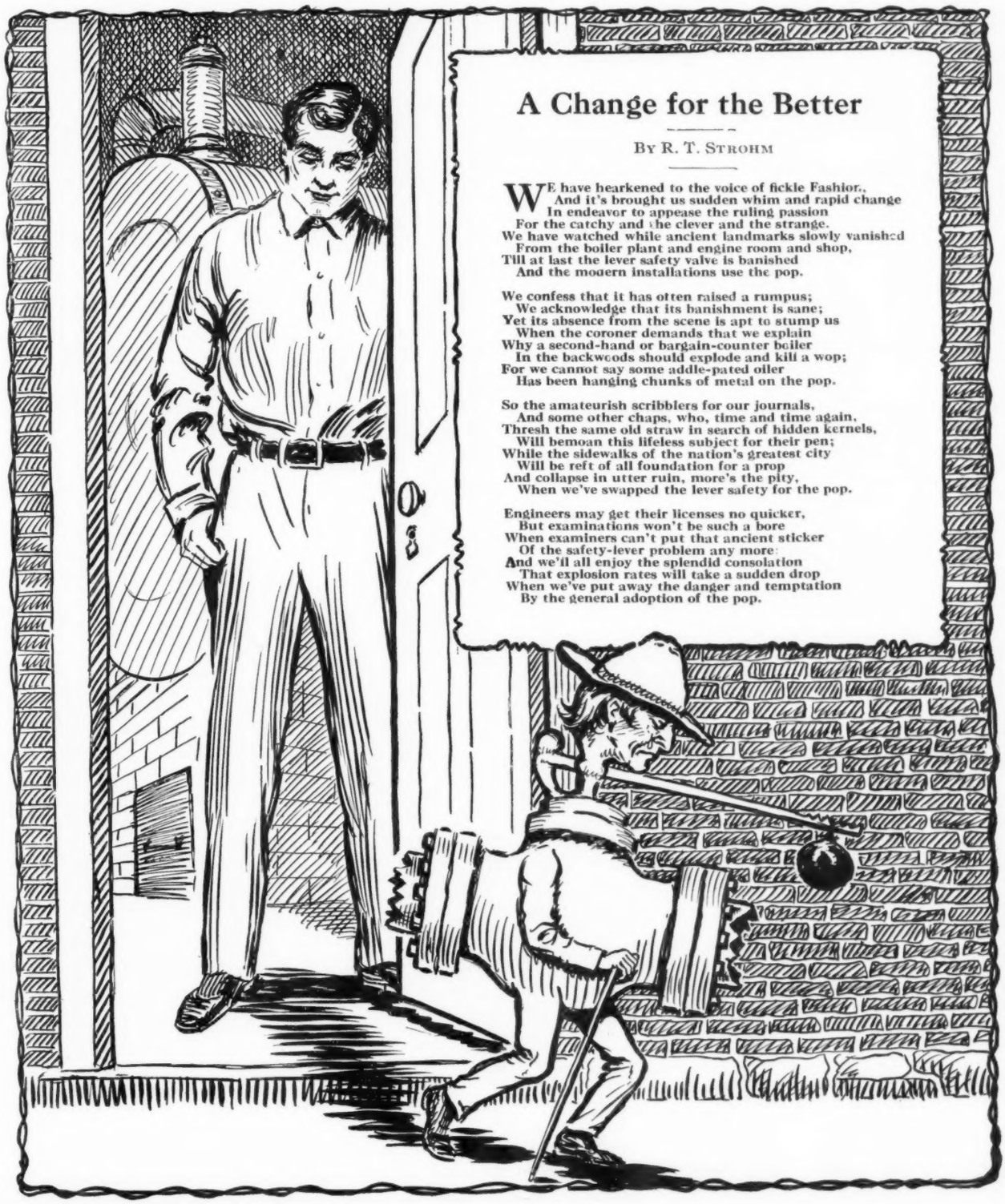


A Change for the Better

By R. T. Strohm

We have hearkened to the voice of fickle Fashion,
And it's brought us sudden whim and rapid change
In endeavor to appease the ruling passion
For the catchy and the clever and the strange.
We have watched while ancient landmarks slowly vanished
From the boiler plant and engine room and shop,
Till at last the lever safety valve is banished
And the modern installations use the pop.

We confess that it has often raised a rumpus;
We acknowledge that its banishment is sane;
Yet its absence from the scene is apt to stump us
When the coroner demands that we explain
Why a second-hand or bargain-counter boiler
In the backwoods should explode and kill a wop;
For we cannot say some addle-pated oiler
Has been hanging chunks of metal on the pop.

So the amateurish scribblers for our journals,
And some other chaps, who, time and time again,
Thresh the same old straw in search of hidden kernels,
Will bemoan this lifeless subject for their pen;
While the sidewalks of the nation's greatest city
Will be reft of all foundation for a prop
And collapse in utter ruin, more's the pity,
When we've swapped the lever safety for the pop.

Engineers may get their licenses no quicker,
But examinations won't be such a bore
When examiners can't put that ancient sticker
Of the safety-lever problem any more:
And we'll all enjoy the splendid consolation
That explosion rates will take a sudden drop
When we've put away the danger and temptation
By the general adoption of the pop.

Power Plant at Mooseheart

By Thomas Wilson

SYNOPSIS—Small alternating-current plant uptodate in design and construction. Complete coal- and ash-handling facilities. Several interesting kinks have been introduced by the engineer.

The power plant of the educational institution conducted by the Loyal Order of Moose at Mooseheart, Ill., supplies the several buildings already erected with light, heat and water. It has been designed with a view to future additions as the completion of new buildings adds to the load. The plant has been centrally located, and distribution of steam and electrical energy will be effected through an adequate system of tunnels and conduits.

The walls of the power plant are of concrete blocks with a granite finish on the outside; on the inside they are plastered and enameled white. Two-thirds of the wall area is glass, the windows being operated by mechanical opening devices. In the boiler room half of the wall area is glass, and there is a monitor across the roof. Semi-indirect lighting is employed in the engine room, and in the boiler room there is a shower and toilet.

The boiler plant supplies steam for the generator engine and live steam at 60 lb. pressure for the laundry, the kitchen of the dining hall and the hot-water service tanks in all the buildings. Steam at the same pressure also heats twelve buildings, a total of 12,466 sq.ft. of direct radiation, all supplied by two-pipe systems. The returns are trapped to an open tank in each building and are pumped to a closed heater to be used for domestic purposes. The live steam brought to each building is available to raise the temperature of the returns if necessary.

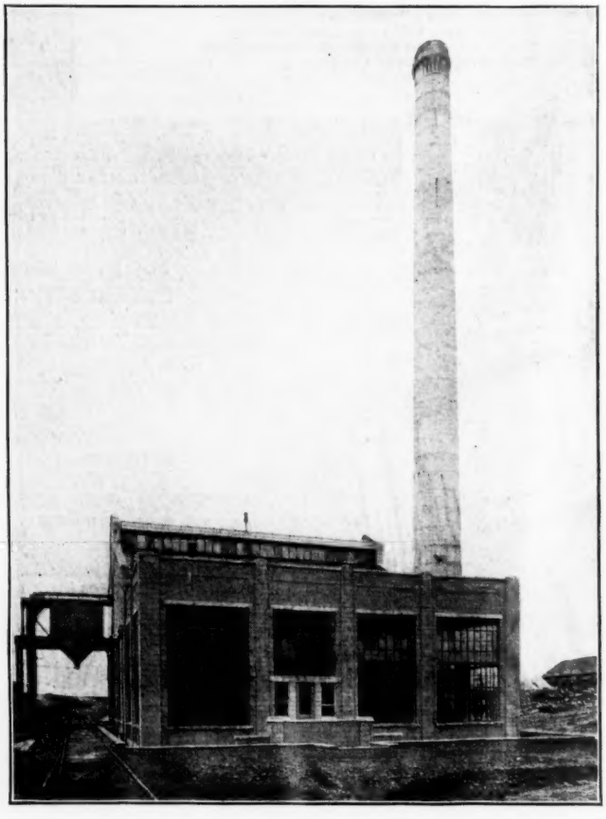


FIG. 1. POWER PLANT AT MOOSEHEART

Exhaust steam from the generator engine is used to heat the dining hall, which has 2,079 sq.ft. of direct radiation; it will also be used to heat the print shop and industrial building, having 7,000 and 5,000 sq.ft. of direct radiation respectively. The load on the engine is not heavy, and if the supply of exhaust steam proves inadequate, reducing valves make the high-pressure supply available. The tunnel lines are so cross-connected with the high-pressure and exhaust steam piping that it is possible to supply steam at the boiler pressures of 125 lb., 60 lb., 40 lb. and at atmospheric pressure. The exhaust heating is effected by a vacuum system, a vacuum of 6 in. being maintained at the pump, which is in the tunnel at the power house. A back pressure of 2½ lb. is imposed on the engine.

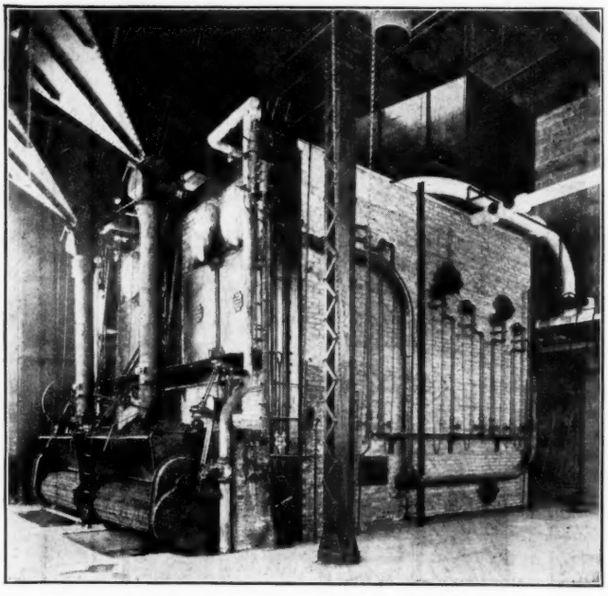


FIG. 2. THE TWO 372-HP. BOILERS NOW INSTALLED

The boilers, Fig. 2, are of the double-drum horizontal water-tube type having vertical baffles providing three gas passages. Two 372-hp. boilers have been installed, and the foundations and blanked connections in the feed-water line and steam headers have been provided for two additional units of the same size. Each boiler has 3,725 sq.ft. of heating surface and a chain grate having 82.6 sq.ft. of effective area, the ratio being 1 to 45. The stoker shaft is belt-driven by a vertical duplex engine, and natural draft is produced by a concrete chimney 175 ft. high and 8 ft. in diameter at the top. The gases from the third pass flow up around the drums into a rectangular steel breeching of uniform section having an area of 60 sq.ft. Figured from its diameter the stack has an effective area of 50 sq.ft., so that for every 1,000 sq.ft. of boiler-heating surface there are 22 sq.ft. of connected grate surface, 8 sq.ft. of breeching and 6.7 sq.ft. of stack area. As high as ¾ in. of draft over the fire is available. With Franklin Co. screenings the boilers

at light load have been evaporating 8 to 9 lb. of water per pound of coal as fired.

Efficiency meters show the drop in draft from the fire to the breeching, and it is the intention soon to put in a CO_2 recording meter and a gage to record the temperature of the gases as they leave the heating surface. Soot blowers are provided, and there are water-service lines front and back. The former provides water for washing the boilers and for operating the turbine tube cleaner. From the service line at the rear, taps lead through the boiler setting for wetting down the combustion chamber. This can be readily done before cleaning by manipulating a valve in the line. Another convenience is a double door in the bridge-wall so that the soot in the combustion chamber may be shoveled into the ashpit. There is a tight-joint door on either side of the wall, and the door frames are cemented in to guard against leakage.

At the front and rear of the boilers lattice-work treads mounted on angle-iron supports make cleaning easier.

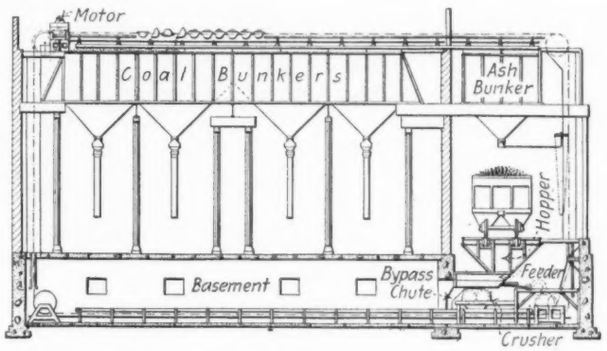


FIG. 3. LAYOUT OF COAL-HANDLING EQUIPMENT

The blowoff valves are 5 ft. above the floor, with all fittings in plain view and readily accessible.

An interesting feature is the damper control at the front of the boilers. At the side of the settings a ratchet handle is mounted about 30 in. from the floor. A 1-in. tube connects the handle to one arm of a bell crank mounted at the top of the setting. The other arm connects with the damper at the rear of the setting. Its position can be easily adjusted, and the damper is sure to stay in the position in which it has been set.

Another innovation is the use of lead-composition gaskets for the tube headers. When tearing down for washing, the usual rubber gasket is destroyed. The lead gasket can be remolded with a loss of only 10 per cent. in the material. The engineer of the plant first made up a number of these lead gaskets from a plaster of paris mold. They were tried out for two washings and proved so successful that a pattern and cast-iron mold were made. The rubber gaskets cost on an average about 5c. apiece. The first cost of the composition gaskets proved to be 1.9c., including material, labor and gasoline for melting. As 90 per cent. of the material is recovered, the average cost of each gasket should be well under 1c.

The boilers are in a row at right angles to the railroad siding over which coal is delivered. Individual steel bunkers of 40 tons' capacity and concrete-lined serve each boiler, and an ash bunker, placed in line with the coal bunkers, is suspended above the track, as shown in Fig. 3. A pivoted bucket carrier, having a capacity of 30 tons per hour, passes above this row of bunkers and beneath the track hopper and the ashpits.

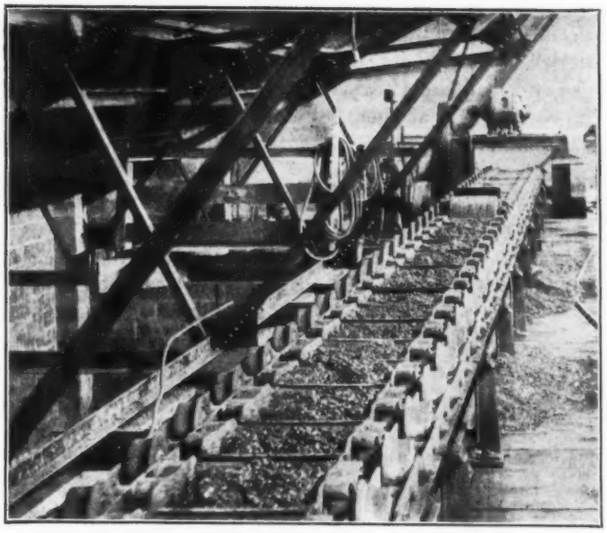


FIG. 4. UPPER RUN OF BUCKET CARRIER

Coal from the railroad car is dumped into a standard 12x12 ft. steel track hopper integral with a reciprocating steel plate feeder. When necessary the coal is fed into a 24x20-in. double-roll crusher driven by an individual motor. Ordinarily, fine coal will be received at the plant, and for this the feeder is set to discharge into the bucket carrier, which has 41-ft. vertical centers and is 81 ft. long between horizontal centers. Using a traveling tripper the buckets may be dumped into any one of the four elevated bunkers, the position of the tripper being controlled from the boiler-room floor. The conveyor is driven by a 7½-hp. motor placed above the upper run of the conveyor (see Fig. 4). The controller is on the boiler-room wall immediately under the motor, but as the latter is not visible from this point, it is the intention of the engineer to set two mirrors so that a reflection of the motor can be seen down at the controller.

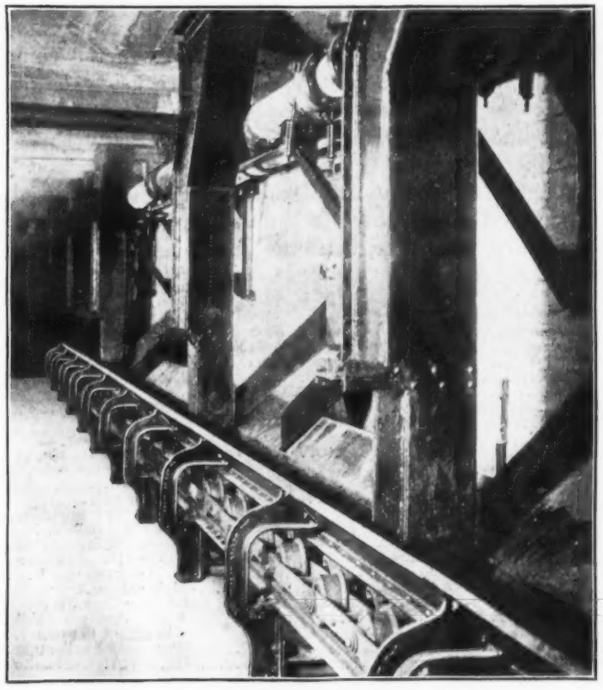


FIG. 5. COAL AND ASH CARRIER IN BASEMENT

The ashes collect in pits beneath the stokers and by special tubes, shown in Fig. 5, are fed directly into the carrier, which is set to discharge into the ash bunker. The stoker siftings also collect in special steel spouts over the carrier so that their contents may be delivered to the coal bunkers above and eventually find their way back to the boiler furnaces.

From the bunkers the coal is delivered to the stoker magazines through measuring spouts. The gates at each end of the spout are interlocked, and a counting mechanism is attached to the interlocking device, which automatically records the number of charges delivered to the hopper of the stoker. This arrangement was adopted in preference to a traveling weigh-hopper on account of its simplicity and the automatic recording feature. The spout is calibrated for weight and allowance made for the water content of the coal, so that the record, reduced to pounds of coal, is accurate enough for all practical purposes. The water supply for the entire institution comes from wells on the premises drilled 1,840 ft. to Potsdam sand. All water above this level is cased off so that the supply is soft and contains little scale-forming matter. From the main supplying the plant this water is introduced into a 1,200-hp. open heater by float control. It is used as makeup, as the returns from the exhaust steam heating are not sufficient to supply the demands of the boiler. The two boiler-feed pumps, Fig. 8, of the outside-packed type and controlled by pressure governors, are below the heater, the equipment being located in the engine room. Exhaust from the feed pumps maintains the temperature in the heater at about 200 deg. F. Between the pumps and the boilers is a venturi meter for measuring the feed water. As there is a cold supply in addition to the hot-water line, the meter is so connected that it can be used on either.

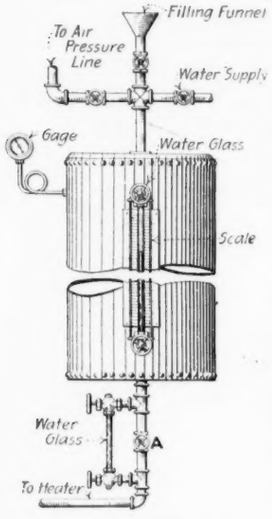


FIG. 6. COMPOUND FEEDER

Although there is little scale-forming matter in the boiler feed water there is an abundance of magnesia. Compound was first fed into the boilers, and as the precipitation resulting required frequent cleaning, it was decided to introduce the compound into the heater, from which the resulting sludge could be removed much easier. The compound feeder, Fig. 6, consists of a galvanized drum 14 in. diameter and 30 in. high, built for high pressure. At the top this drum has air and water connections and a funnel through which the compound is introduced. The drum has a gage to show the pressure and a water glass with a calibrated scale back of it to indicate the amount of compound in the drum. The feed is continuous and may be regulated by adjusting the valve *A* and the air pressure above. Ordinarily, however, valve *A* is closed and the feed is regulated by the top valve of the water column bypassing it. In this way the feed is visible and any stoppage may be detected.

The main 200-kv.-a. generating unit is the only one installed at present. The engine is of the four-valve type, 17x20 in., making 200 r.p.m., the steam pressure being 125 lb. The directly driven generator is a three-phase

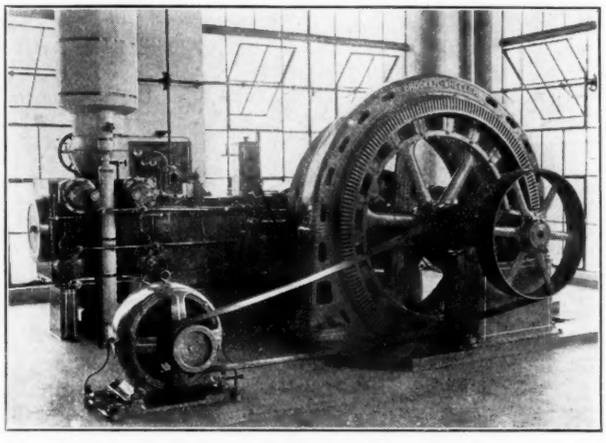


FIG. 7. THE 200-KV.-A. GENERATING UNIT

60-cycle machine delivering current at 2,300 volts. The exciter, rated at 9 kw., is belted to the generator shaft. The unit complete is shown in Fig. 7.

Current is driven at 2,300 volts. A transformer in each zone, including a group of buildings, reduces the pressure to 220 and 110 volts, the former voltage being used for power and the latter for lighting. All power over 5 hp. is three-phase and the single-phase lighting is balanced as nearly as possible.

At present the load is light, but with the addition of the print shop and industrial building it will be consid-

PRINCIPAL EQUIPMENT OF MOOSEHEART POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Boilers	Water tube	372-hp.	Generate steam	Press. 125 lb., natural draft, stokers	S. Freeman & Sons Mfg. Co.
2	Stokers	Chain-grate	82.6 sq.ft.	Serve boilers	Driven by duplex engine	Manistee Iron Works
1	Engine	Vertical duplex	5-hp.	Drive stokers	125-lb. steam, belted	Sterling Machine Co.
2	Meters	Efficiency		Drop in draft		W. A. Blouck & Co.
1	Stack	Concrete	175 ft. high, 8 ft. diam.	Serve boilers		Weber Chimney Co.
1	Carrier	Pivoted-bucket	15x18-in., 30 tons per hr.	Elevate coal and ash to bunker	Driven by 7½-hp. C. W. motor	Stephens-Adamson Mfg. Co.
1	Track hopper	Steel	12x12-ft.	Receive coal from Ry. cars		Stephens-Adamson Mfg. Co.
1	Feeder	Reciprocating		Feed coal into crusher or carrier		Stephens-Adamson Mfg. Co.
1	Crusher	Double-roll	24x20-in.	Crush coal	Driven by 13-hp. C. W. motor	Stephens-Adamson Mfg. Co.
4	Bunkers	Steel, concrete-lined	40-ton	Serve boilers		Stephens-Adamson Mfg. Co.
1	Heater	Open	1,200-hp.	Heat boiler-feed water	Exhaust steam, water 200 deg. F.	Platt Iron Works
2	Pumps	Duplex	8x5x10-in.	Boiler-feed water	Steam 125 lb. press	Platt Iron Works
1	Meter	Venturi	3x1¼-in.	Measure boiler-feed water		Builders Iron Foundry
1	Pump	Vacuum	8x10x12-in.	Exhaust heating system		International Steam Pump Co.
1	Engine	Four-valve	17x20-in.	Main generating unit	125 lb. steam, 200 r.p.m.	Ball Engine Co.
1	Generator	Alternating current	200-kv.-a.	Main generating unit	3-phase, 60-cycle, 2,300-volt, 200 r.p.m.	Crocker-Wheeler Co.
1	Exciter	Belted	9-kw.	Excite main generator	Belted to generator shaft, 700 r.p.m.	Crocker-Wheeler Co.
1	Pump	Centrifugal	2-in.	Raise drainage boiler-room basement to sewer	Driven by 3-hp. Westinghouse Motor, aut. control	Hill Pump Co.
2	Soot blowers	Steam		Blow soot off boiler tubes		Vulcan Soot Cleaner Co.
	Heating system	Crescent		Heating bldgs. of institution	Exhaust and live steam	W. H. Pearce Co.

Switchboard and all instruments, Westinghouse; Valves in power plant and all gages, Crosby; High-pressure traps, Cranetilt; Low-pressure traps and reducing valves, G. M. Davis.

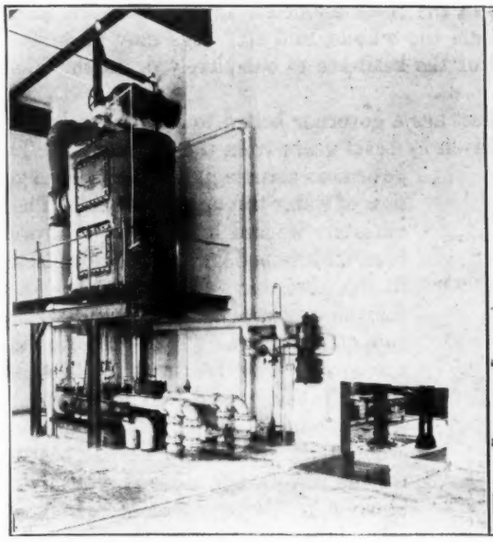


FIG. 8. HEATER AND FEED PUMPS

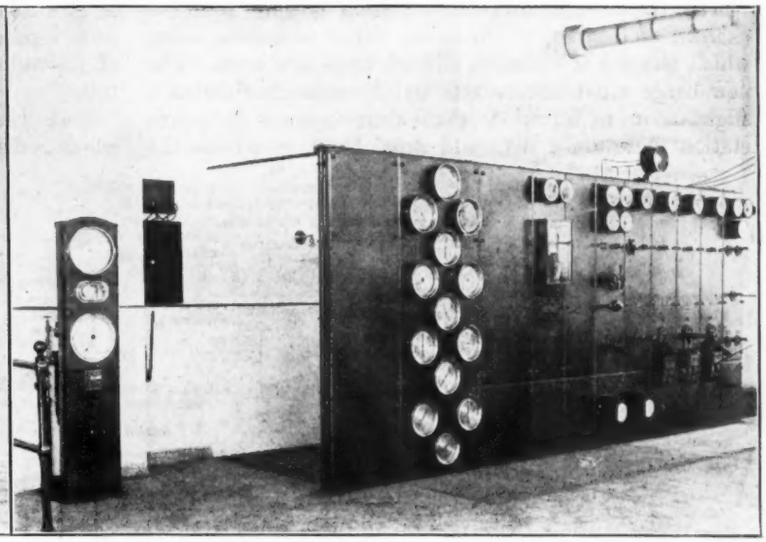


FIG. 9. THE SWITCHBOARD AND VENTURI METER

erably increased. As other contemplated buildings are completed, there will be need for another generating unit. There is plenty of space in the engine room for it and also for a refrigerating plant, which it is the intention to install at an early date. Series street lighting by 200-watt nitrogen-filled lamps now going in will also add to the load.

The switchboard, Fig. 9, contains eight 16-in. panels of black monson slate. On it are the usual ammeters, voltmeters, watt-hour meters, a frequency indicator, a power-factor meter, a ground detector and a potential regulator. In addition to the power and lighting circuits the board provides for three arc-lamp circuits and for breakdown service. One panel also has indicating and recording gages for steam, water and air pressures and vacuum on the exhaust-steam heating system. Just to the left of the board is the indicating, integrating and recording venturi meter.

All high- and low-pressure steam and hot water piping is covered with 85 per cent. magnesia. The valves are of the spring-seated interchangeable disk type. To distinguish readily between the different piping systems, the following color scheme has been adopted: All piping carrying steam above 10 lb. is white; for steam below 10 lb., yellow; for hot water, red; for cold water, sky blue; for dirty drains, apple green; and for air, black.

Robert F. Havlik, resident engineer of Mooseheart, supervised the design and construction of the power plant and heating system, for which W. H. Pearce & Co., Chicago, were the contractors. Fred W. Husk is supervising engineer for the institution, and J. J. Spangler is chief operating engineer of the power plant.

Waterloo Hydro-Electric Plant

By Norman G. Meade

SYNOPSIS—A 3,000-hp. low-head plant operating in parallel with a number of steam stations and purchased hydro-electric power on the system of the Empire Gas and Electric Co., which serves a number of cities in central New York.

The Empire Gas and Electric Co. supplies light and power to Auburn, Seneca Falls, Waterloo, Geneva, Palmyra, Phelps, Newark and Lyons, N. Y. The system includes four steam generating stations, one hydro-electric station at Waterloo, and several transformer stations and substations. The distance from Auburn, the eastern end of the system, to Geneva is 26 mi.; from Geneva to Palmyra is approximately 12 mi. in a northwesterly direction, and from Auburn to Lyons, 20 mi. The system is represented diagrammatically in Fig. 1.

In the cities and towns where the generating stations are situated there was a heterogeneous collection of equipment for both direct- and alternating-current supply as well as series arc-light machines. The alternating-current frequency was 60 cycles with 2,300-volt distributing systems. When the Empire Gas and Electric Co. consolidated the various equipments into one system, it made provision for using Niagara Falls and Salmon River power when necessary or expedient. These two sources have a frequency of 25 cycles and a voltage of 60,000. The Niagara Falls line is tapped at Lyons, and both Niagara Falls and Salmon River power are received in Auburn. The transmission lines of the Empire company operate at 13,200 volts and 60 cycles, but will eventually be changed to 23,000 volts by changing the connections of the high-tension side of the step-up transformers from delta to star.

Aside from the steam generating station at Auburn, there is a substation in the north end of the city with an equipment of transformers and frequency changers for transforming the Niagara Falls and Salmon River power from 25 cycles 60,000 volts to 60 cycles 2,300 volts. There are two 600-kw. and two 300-kw. frequency changers and two banks of three transformers, aggregating 3,000 kv.-a. The hydro-electric plant, which has a fairly constant head, operates in parallel with the steam stations, and the Niagara power takes care of the peaks.

The Waterloo hydro-electric station is built over the channel of the Seneca River, the outlet of Seneca Lake, which is some seven miles distant from the town. The new barge canal utilizes this water course, but makes a slight detour in Waterloo. Some distance above the power station there are a dam and canal locks, and from the dam to the power station the river forms the headrace. The normal head at the station is 14.5 ft. In the station there are four Allis-Chalmers vertical submerged-type waterwheels, each rated at 750 hp. and connected to a three-phase 2,300-volt 90-r.p.m. generator rated at 150 amp. per terminal. The overall diameter of the generators is 17 ft. and the rotor diameter, 14 ft. Concrete partitions separate the wheels, and stop logs may be lowered at the end of the headrace to completely drain the wheel pits.

Each wheel has a governor belted to a horizontal shaft, which is driven by bevel gears from the main shaft. The governors actuate gates that control the flow of water through the wheels. These gates are worked by oil at 160 lb. pressure maintained by a pump connected to the governor. The generators have Kingsbury suspension thrust bearings supporting the weight of the revolving elements. The bearings are flooded, the oil being pumped to them by small pumps belted to the governor shaft. There is no lower bearing for the wheels, but there is a steadying bearing in the generator arch immediately below the thrust bearing and a lignum vitæ bearing above the watershed. For stepping up the station voltage of 2,300 to the transmission voltage of 13,200, there is a bank of three 1,000-kv.-a. oil-insulated, self-cooled transformers connected delta-delta, with remote-control oil switches on the high-tension side actuated from the switchboard. Excitation is furnished by two motor-generator sets and a 50-cell storage battery, the latter being used for starting up a unit when all have been shut down. The battery has sufficient capacity to excite one generator at one-fourth load for twenty minutes. It is charged in two groups of 25 cells connected in multiple. Each of the two exciter

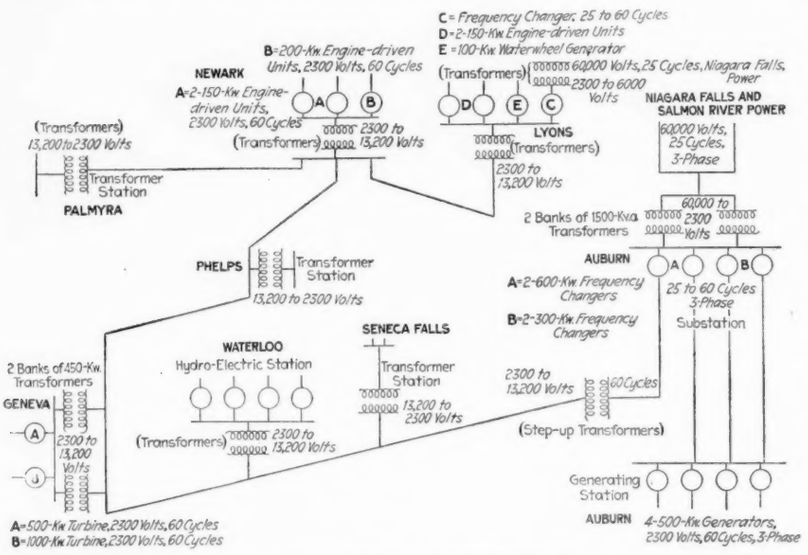

C = Frequency Changer, 25 to 60 Cycles
D = 2-150-Kw. Engine-driven Units
E = 100-Kw. Waterwheel Generator
B = 200-Kw. Engine-driven Units, 2300 Volts, 60 Cycles
NEWARK
A = 2-150-Kw. Engine-driven Units, 2300 Volts, 60 Cycles
(Transformers) 2300 to 13,200 Volts
(Transformers) 2300 to 6000 Volts
(Transformers) 60,000 Volts, 25 Cycles, Niagara Falls, Power
NIAGARA FALLS AND SALMON RIVER POWER
60,000 Volts, 25 Cycles, 3-Phase
LYONS
(Transformers) 2300 to 13,200 Volts
(Transformers) 13,200 to 2300 Volts
Transformer Station
PALMYRA
2 Banks of 1500-Kva. Transformers 60,000 to 2300 Volts
AUBURN
A = 2-600-Kw. Frequency Changers
B = 2-300-Kw. Frequency Changers
25 to 60 Cycles 3-Phase Substation
PHELPS
Transformer Station
13,200 to 2300 Volts
SENECA FALLS
Transformer Station
13,200 to 2300 Volts
WATERLOO
Hydro-Electric Station
(Transformers) 2300 to 13,200 Volts
2 Banks of 450-Kw. Transformers
GENEVA
2300 to 13,200 Volts
2300 to 13,200 Volts
60 Cycles
(Step-up Transformers)
Generating Station
AUBURN 4-500-Kw. Generators, 2300 Volts, 60 Cycles, 3-Phase
A = 500-Kw. Turbine, 2300 Volts, 60 Cycles
B = 1000-Kw. Turbine, 2300 Volts, 60 Cycles

FIG. 1. DIAGRAM OF POWER SYSTEM

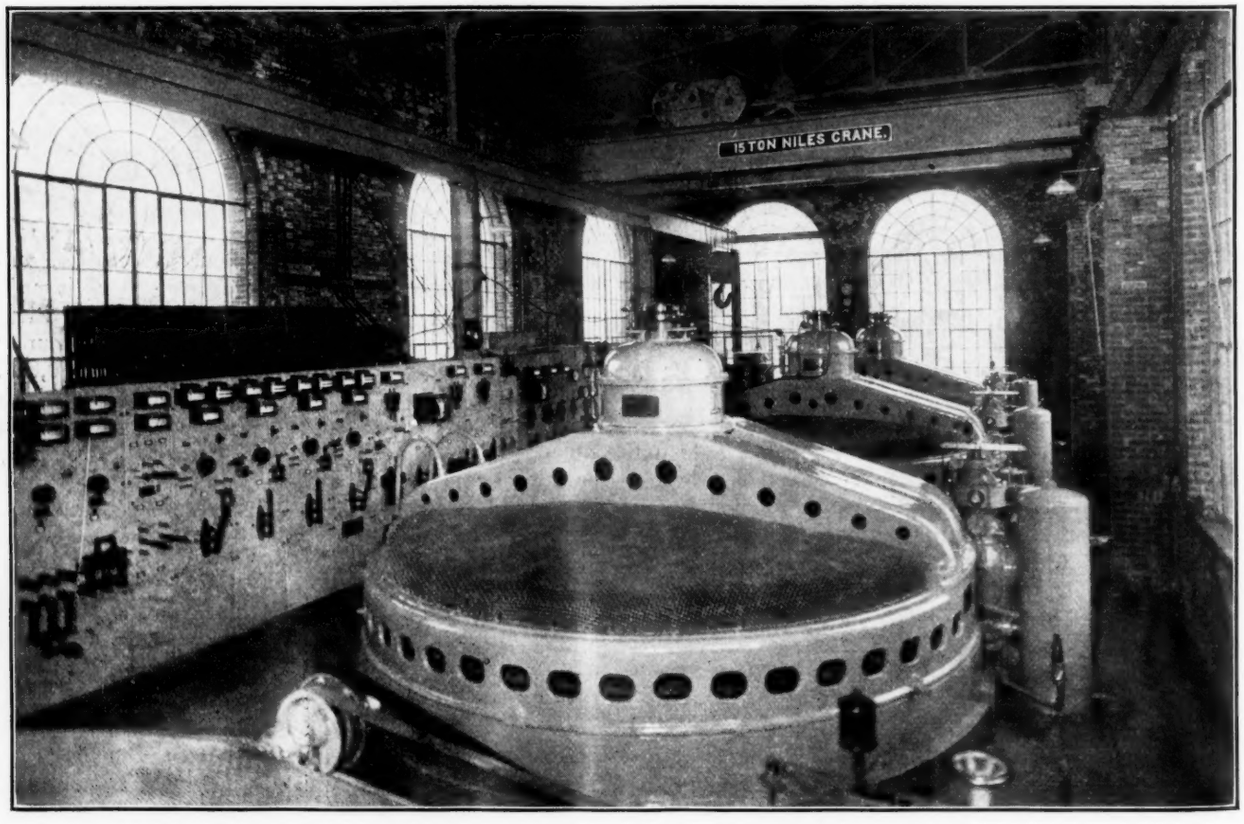


FIG. 2. GENERATING UNITS IN WATERLOO HYDRO-ELECTRIC PLANT

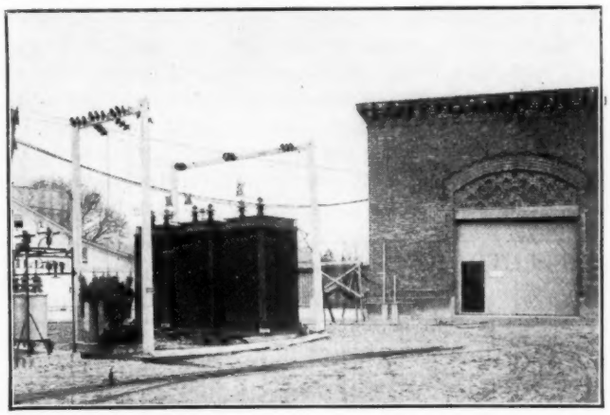


FIG. 3. OUTDOOR SUBSTATION, WATERLOO

units consists of a 150-hp. three-phase 2,300-volt induction motor direct-coupled to a 125-volt 800-amp. direct-current generator running at 860 r.p.m. One unit will handle all four generators, but the two may be operated in parallel, for which equalizer connections are provided. A Tirrill regulator is used in connection with the exciters.

Besides furnishing power to the transmission lines and the local town load, energy is also supplied to the Geneva, Seneca Falls & Auburn Ry. through a transformer bank and a rotary converter. The latter is a six-phase machine with an alternating-current voltage of 437 and a direct-current voltage of 600. It is started from the alternating-current side with a starting voltage of 171 volts. The transformer bank consists of three 165-kv.-a. oil-insulated self-cooled transformers connected delta on the primary side and double-delta on the secondary side. The negative brushes of the direct-current side of the converter are connected directly to the ground without intervening switches. Control of the rotary converter is obtained from the necessary instruments on two panels of the main switchboard, consisting of two 2,800-volt circuit-breakers on the alternating-current side; two direct-current ammeters reading to 1,400 amp.; a switchboard-type watt-hour meter; a 600-volt circuit-breaker of 1,000 amp. capacity for the direct-current feeders, an ammeter reading to 2,000 amp., and a rheostat.

The main switchboard is of light-colored marble, carrying at the left a bracket panel upon which are mounted a synchroscope, voltmeter, frequency meter and Tirrill regulator. The two exciter panels contain two three-pole exciter switches, the exciter-field rheostat; two ammeters and two voltmeters. The storage-battery panel is equipped with a two-pole charging switch and two single-pole double-throw switches for changing the battery connections from series to parallel, as already explained; also a voltmeter, ammeter and charging rheostat. Each of the four generator panels contains a kilowatt-hour meter, a power-factor meter, an ammeter and field rheostat handles, with the rheostats mounted above the board, besides a field switch and a generator oil switch. There is a totalizing panel with the usual instruments, and switches for the remote control of the transformer secondary switches. Transfer panels and feeder panels complete the board.

Auburn is the largest city on the system and has a large power load, current being furnished to such corporations as the International Harvester Co., the Columbian Rope Co. and the Kilmonarch Carpet Co. From the Auburn substation at the outskirts of the city, three 2,300-volt tie feeders run to the generating station through the street subways. The station is located in the business center and before its rehabilitation contained several arc-light generators and supplied a large number of 500-volt direct-current motors. The exhaust steam at present is utilized

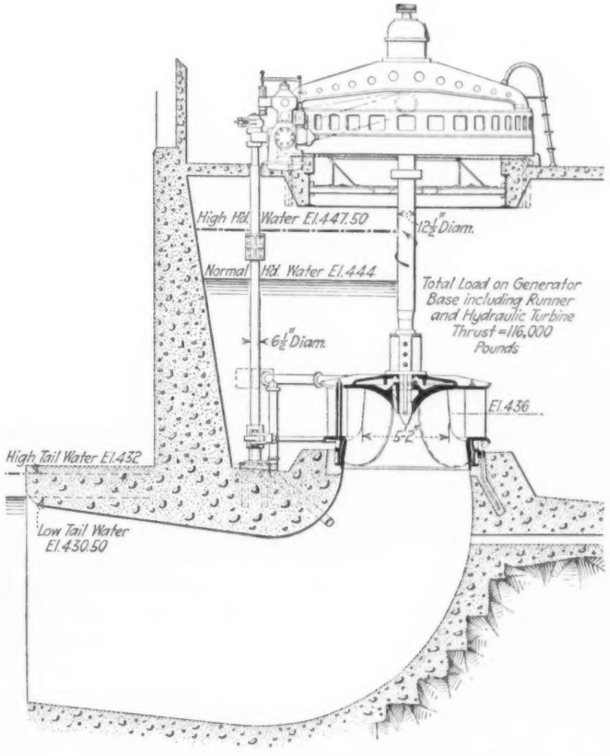


FIG. 4. SECTION THROUGH TURBINE

for district heating in the business section within a half-mile radius of the station.

Steam is furnished by one Stirling and five Heine boilers having a combined rated capacity of 1,860 boiler-horsepower. They operate at 150 lb. pressure and are hand-fired.

PRINCIPAL EQUIPMENT OF WATERLOO HYDRO-ELECTRIC STATION

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Waterwheels	Vertical	750-hp.	Main units	Average 14½ ft. head-water, 90 r.p.m.	Allis-Chalmers Mfg. Co.
4	Generators	Horizontal	150-amp. per term.	Main units	2,300 volts, 90 r.p.m.	Allis-Chalmers Mfg. Co.
1	Rotary converter	A.-c. to d.-c.	500-kw.	Supplies Interurban R.R.	Six-phase, d.-c. volts 600, a.-c. volts 457	Westinghouse Elec. & Mfg. Co.
2	Motor-generators	A.-c. to d.-c.	150-hp. motor 125-volt, 800-amp. generator	Exciters	2,300 volts a.-c., 125-volts d.-c., 860 r.p.m.	Allis-Chalmers Mfg. Co.
3	Transformers	Oil-insulated; self-cooled	1,000-kv.-a.	Step up to transmission voltage	2,300 volts to 13,200 volts	General Electric Co.
3	Transformers	Oil-insulated; self-cooled	165-kv.-a.	Rotary converter	2,300 to 437 volts, three-phase to six-phase	Westinghouse Electric & Mfg Co.
1	50-cell storage battery	Lead-plate		Auxiliary exciting current	Carry one machine ¼ load for 20 min.	Electric Storage Battery Co.
1	Traveling crane	Electric	15-tons	General	125 volts direct current	Niles-Bement-Pond

The generating equipment is a combination of steam-turbine and reciprocating-engine units. There are two 500-kw. 2,300-volt three-phase turbo-generators served by jet condensers, one 25x50x42-in. simple noncondensing horizontal engine driving a 540-kw. three-phase 60-cycle generator, and two vertical cross-compound noncondensing units of 480 and 350 hp. respectively, connected by a shaft with friction clutches at each engine. Connected to this shaft is a 500-kw. alternating-current generator. When not in use for generating power, this machine runs as a synchronous condenser for improving the power factor of the system; the engine clutches being released during such periods. To this shaft is also belted a 500-volt direct-current generator, which supplies the few remaining 500-volt direct-current motors that remain in the city. From one of the reciprocating units the exhaust is run to the second stage of the turbines, and they run partially as low-pressure machines when the exhaust steam is not needed for the heating system.

There is a motor-driven exciter set which formerly served the turbo-generators, but when the latter were running in synchronism with Niagara power the surges that sometimes occurred on the line caused fluctuations in the exciter speed, and as a consequence the turbo-generators and the reciprocating unit, which had a belted exciter, were thrown out of synchronism. Now the exciter for the latter supplies excitation current for the former.

From this station the load-dispatching for the entire system is carried on by wireless telegraphy and telephones. On one side of the dispatcher's office there is a large chart board showing the location of all the switches and transmission lines. The company keeps an elaborate system of records which detail the daily output, labor and fuel expenses, repairs, etc. (see Fig. 5).

EMPIRE GAS AND ELECTRIC CO.

STATION No. 3. Daily Report Beginning 7 A. M. Oct 8 1915

Time	Generator Output No. 9	No. 10	No. 11	No. 12	Total Gen.	Used by Exciters	Total Output	Gate Opening No. 9	No. 10	No. 11	No. 12	Water Level Head Race	Tail Race	Ft. Head	A. C. Voltage	Frequency	Pr. Fact	Weather	Railway Amp.	Volts	Pr. Fact	Waterloo Local
7.00 A. M.		200			500				75			446.3	430.0	16.3	2100	60.5	.74	Pt Cloudy	390	650	81	84
7.30																						
8.00																						
8.30																						
9.00																						
4.30																						
5.00																						
5.30																						
6.00																						
6.30																						

WATTMETER READINGS

	Total Gen.	Total Gen.	Exciter	Station	Trolley	Waterloo
Present Readings	009972	1031	6135		2645	4178
Previous Reading	00938.8	6900	6061		5444	3081
Difference	134	131	74		201	1097
Constant	1000	100	10		10	2
Kilo watt hours	13400	1311	740		2012	2194

REMARKS:

Total K. W. Generated 13100
Used by Station 740
Total K. W. Output 12360
Average Load 515
Max. Peak 820
Load Factor 63
Lake Level
Prevailing Wind West
Precipitation Rain Snow
All day Plant efficiency

FIG. 5. DAILY REPORT IN USE AT WATERLOO HYDRO-ELECTRIC PLANT

From one of the reciprocating units the exhaust is run to the second stage of the turbines, and

Coking and Caking Coal

By S. H. Viall

SYNOPSIS—The terms caking and coking defined. Draft over fire and drop through setting as indications of air supply. Furnace specifications and rate of combustion.

The terms "coking" and "caking" as applied to the characteristics of coal are often used synonymously. That they are not identical can be readily understood by considering coal from different sections of the country. All bituminous coals coke while burning; that is, all bituminous coals go through the process of giving off their volatile matter and moisture. In this distillation long yellow to white flames are produced. The fixed substances of the coal remain on the grates in the form of coke and burn by sublimation with a red to white color and with practically no flame.

Caking coal has the characteristic of fusing together in the fire, thus tending to form one common honeycombed lump or mass. The caking takes place during the process of coking. In the caking coals of eastern Ohio, Pennsylvania and West Virginia the tendency to fuse or mass together is marked. This fusing action imposes a high resistance to the passage of air through the fuel bed on account of the partial closing of the spaces between the pieces of the coal. On the other hand, the free burning or noncaking coals, such as are mined in Indiana and Illinois, have but slight tendency to fuse during the coking process. Only a few pieces will occasionally attach themselves to one another.

The resistance offered by different fuel beds to the flow of air varies because of the difference in the caking qualities of the coal, the thickness of the fuel bed, blanketing clinker and the quantity of loose ash upon the grates. These factors all have an influence upon the coal-burning capacity of any furnace, and their constantly changing conditions cause draft readings over the fire to vary.

How to Deal with a Caking Coal

The influence of the caking of the fuel on the draft intensity in a furnace is shown in the table. The data were taken under operating conditions on a hand-fired return-tubular boiler depending upon natural draft and equipped with 25 sq.ft. of grate surface carrying a fuel bed 6 to 7 in. thick.

DRAFT IN A RETURN-TUBULAR BOILER

No. of Reading	Draft Over Fire, In.	Draft Under Grates, In.	No. of Reading	Draft Over Fire, In.	Draft Under Grates, In.
1	0.24	0.04	4	0.31	0.025
2	0.27	0.03	5	0.24	0.04
3	0.29	0.03	6	0.43	0.36

The first reading was taken immediately after the fire had been broken up with the hook and the grates shaken. Readings Nos. 1, 2, 3 and 4 were taken at approximately 5-min. intervals. The only changes in the furnace conditions were the natural action of the coal when burning and the addition of six shovelfuls of coal upon two occasions. Immediately following reading No. 4 the fire was hooked and the grates shaken. No. 5 reading was then taken, which happened to check exactly with the first reading. After getting reading No. 5 the ashpit doors were closed and the sixth set of observations made. The ashpit doors were then opened, and in a few minutes the fire had caked so that the draft was 0.3 in. over the fire. In this particular plant this meant that the fire needed hooking to keep up steam.

To maintain satisfactory capacity with a caking coal it is necessary to break up the cake, or mass, to provide reasonably free passage for the air. In the example cited (natural-draft conditions) the caking, or fusing, characteristic of the coal caused a slow partial closing of the air passages between the pieces of coal in the fuel bed. Less air passed through the fire and reduced the rate at which the coal was burned and in turn the rate of steaming. Choking the air supply to the furnace by the caking of the coal resulted in higher draft intensity over the fire. Closing the ashpit door still farther shut off the air supply to the furnace and resulted in even higher draft over the fire.

Significance of Draft Intensity

Draft intensity is an indication of potential energy. The difference between the draft readings at two points in a boiler setting, such as a point on the boiler side of the damper and another one over the fire, is a rough indication of the work being done in moving the gases through the boiler and setting. A marked increase in the quantity of gas passing through the boiler, other conditions remaining unchanged, would result in an increase of the difference between the draft intensity at the boiler side of the damper and the draft over the fire. Conversely, with a constant draft at the boiler side of the damper and a dropping off of the quantity of gas passing through the boiler, the work of moving the gas would be less, resulting in less drop and consequently a higher draft over the fire. From the foregoing it can be seen that an indication of high draft over the fire of itself means but little unless other details are known.

With the ashpit doors open, a clean fire, ample air space in the grates, a given thickness of fire and a noncaking coal, the higher the draft intensity over the fire the greater the quantity of air entering the furnace and the greater the loss in draft from the boiler side of the damper to the fire. With the same conditions, but with a caking coal, the draft readings over the fire do not necessarily indicate the rate with which air is entering the furnace and coal is being burned. The only time the draft readings over the fire are directly comparable with similar data for noncaking coal is immediately after the fire bed has been thoroughly broken up and the air passages through the fuel bed approach the conditions existing in a fire of noncaking coal.

Data of conditions such as pressures, temperature and speeds, are of value in studying the cause of results in order to work out plans for improvement. To be of use, data must really indicate some definite performance. Draft readings over a fire of given thickness of caking coal tell but little of the air supply to the furnace or of the coal-burning possibilities.

Differential draft gages graduated to read in hundredths of an inch have been designed to obtain further information as to the drop in draft intensity between two points, which in practice are usually taken as the boiler side of the damper and over the fire. To one familiar with studying draft conditions, such data are an indication of the work being done in moving the gases through the boiler. The size, shape and arrangement of the heating surface and baffling of a boiler influence the frictional resistance offered to the flow of the gas and vary with each boiler. Therefore, to carefully study the reasons for results indicated by the loss in draft between the damper and the fire one should have all the details of these different factors affecting the flow of the gas.

Laxity in Specifications Harmful

Those supplying furnaces for boiler work appreciate the widely varying effects that the boiler and its setting have upon the draft available over the fire. The furnace contractor seldom is responsible for anything more than the furnace equipment, and obviously does not wish to be held accountable for results due to conditions beyond his control. Most contracts for boilers and furnaces specify that a given capacity must be obtained. A contract for an installation with natural draft may provide that there shall be 0.3 in. draft over the fire. If this is furnished the contractor agrees that the equipment he supplies will burn coal fast enough to develop the capacity specified. The weak feature of such contracts is that usually there are no stipulations as to what the exact conditions shall be when the draft intensity is determined. Because of this laxity in specifications there is an opportunity for differences between the contractor and the purchaser. If noncaking coal is used, varying the thickness of the fuel bed will change the draft over the fire, while with caking coals the draft over the fires may be high and yet the air supply be insufficient.

In many sections of the country both caking and noncaking coals are available, and the furnace contractor may not know which kind will be used; or if the former, he may not know the characteristics of its fusing qualities.

To avoid possible argument as to what the draft intensity over the fire really is, it is advisable that the specifications provide that the draft shall be determined with a clean fire of given thickness immediately after it has been thoroughly broken up.

Some furnaces make their best performances with a free-burning, noncaking coal. As there may be a difference of opinion as to whether a coal is caking or noncaking, a contractor desiring to make his guarantees with noncaking coal could word his specifications as follows: "There shall be provided a draft of 0.3 in. over the fire at a point 3 ft. inside of the inspection door, with a clean fire 7 in. thick and with the ashpit doors wide open; also the draft at the underside of the grates in the middle of the furnace shall be not less than 0.04 in."

The size of coal to be used would be provided for in another part of the contract. To many engineers specifications such as cited will appear unusual. Let us see just what they require with natural- or induced-draft equipment.

The Importance of the Air Supply

With a clean fire of noncaking coal of a given size, the air passages through the fuel bed remain fairly constant for a given thickness; therefore the resistance to the passage of the air through the fire is practically constant. With a constant draft over the fire and a constant resistance through the fuel bed, there would be, immediately under the grates, a constant draft that would cause the air in the boiler room to flow toward the grates. This condition of partial vacuum or draft intensity immediately under the grates exists in all furnaces using natural or induced draft with no blast or pressure below the grates. The intensity of this draft is an indication of the force impelling air toward the grates. With caking coals the resistance of the fuel bed will increase as the pieces of coal fuse together, resulting in lower draft below the grates. Because of the less pressure difference between this point and the boiler room a less quantity of air will be moved toward the grates.

With fires of noncaking coal from 6 to 7 in. thick, air spaces in the grates of 20 per cent. for self-cleaning mechanical stokers or 50 per cent. for hand firing and natural draft, about 1 lb. of coal per hour can be burned on each square foot of grate for each 0.01 in. intensity of draft over the fire. This ratio will hold up to about 30 lb. of coal per square foot of grate surface per hour.

Under these conditions from 10 to 15 per cent. of the draft intensity above the fire would be available immediately below the grates; that is, with 0.3-in. draft over the fire the draft under would be from 0.03 to 0.045 in.

The fuel bed with some caking coals is more porous than with others, on account of the different fusing characteristics. Since, with a given thickness of fire there is no constant resistance to the flow of air, a general statement of draft intensity required for given conditions cannot be given. The best general information available at present is that caking coal can be burned as rapidly with a given draft as can noncaking coal, if care is used to keep the air passages open by breaking the cake.

Close attention to furnace performance is showing with increasing force the importance of the air supply. Further study will develop more satisfactory methods of determining the cause of many of the phenomena that are but little understood.

A Psychrometric Chart

By Prof. H. L. Parr

The chart is divided into two parts lying to the left and right of the line headed "Dry-Bulb Temperature," which is common to both. The left-hand section shows the relations between relative humidity, saturation temperature (dew point) and dry-bulb temperature, and the right-hand section shows the relation between dry-bulb temperature, wet-bulb temperature and saturation temperature. For either section a straight line passed through the lines representing two of the quantities at any given points will intercept the line representing the third quantity at a point of corresponding condition to the other two. Lines so drawn on the right-hand section can never slope upward to the right, since neither the wet-bulb temperature nor the saturation temperature can be higher than the dry-bulb temperature. The most convenient form of straight-edge to use for the purpose is a thin strip of celluloid with a fine line ruled on the under side.

The table accompanying the chart gives, for every degree of temperature covered by its range, the vapor pressure, pounds of vapor per cubic foot saturated, cubic feet per pound saturated and pounds of vapor per pound of air saturated.

The method in common use of expressing absolute humidity in terms of weight of vapor per unit volume of air makes psychrometric calculations difficult and involved, since a change of temperature changes the volume, and hence the value, of the absolute humidity. It is therefore simpler to express absolute humidity in terms of relative weights, since this relation remains constant for any mixture of air and vapor throughout all temperature ranges so long as no condensation or further evaporation of moisture takes place. The weight of vapor per pound of air in any condition is the weight of vapor per pound of air saturated at its saturation temperature. In other words, all mixtures of air and vapor that have the same saturation temperature have the same weight of vapor per pound of air.

The chart is calculated for a thoroughly ventilated wet bulb.

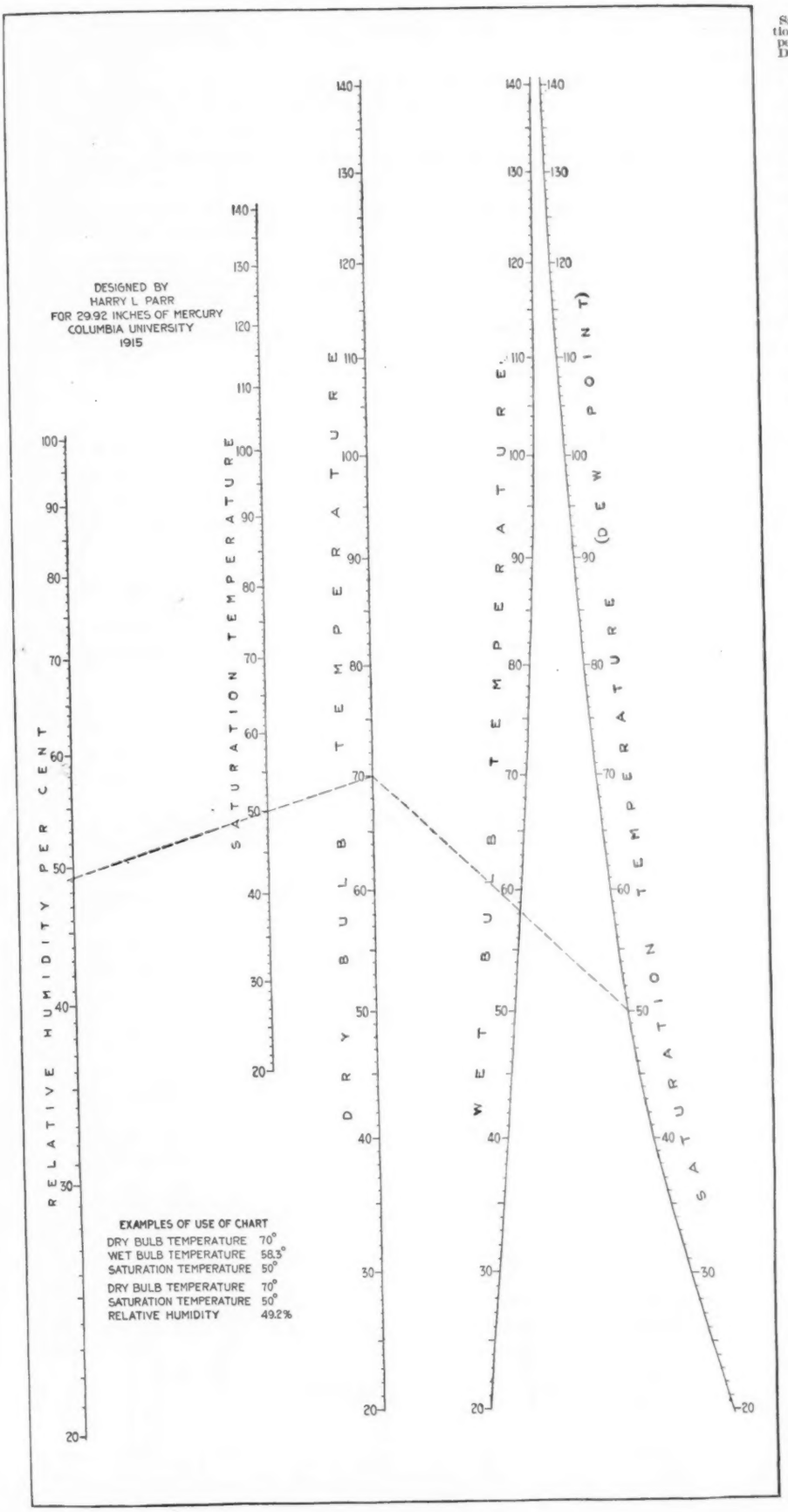
Examples Showing Use of Chart

1. Given dry-bulb temperature = 75 deg., wet-bulb temperature = 67 deg., atmospheric pressure = 29.92 in. mercury; to find the cubic feet of air per pound.

One pound of dry air at 32 deg. and 29.92 in. mercury has a volume of 12.387 cu.ft. The pressure of vapor in the air will be that corresponding to the saturation temperature. A straight-edge laid on the chart with its edge passing through 75 deg. dry bulb and 67 deg. wet bulb will indicate a saturation temperature of 63 deg. From the table it will be found that the vapor pressure corresponding to 63 deg. is 0.580 in. mercury. As the total pressure of the atmosphere is 29.92 in. mercury, the partial pressure of the air will be 29.92 — 0.580 = 29.34. As the volume is proportional to the absolute pressure and the absolute temperature, the cubic feet per pound will be

$$12.387 \times \frac{535}{492} \times \frac{29.92}{29.34} = 13.7$$

2. Air is being supplied to a steam-heated drying kiln. It enters at a dry-bulb temperature of 59 deg. and a wet-



A PSYCHROMETRIC CHART

For solving problems relating to cooling towers, air conditioning, etc.

Saturation Temperature Deg. F.	Vapor Pressure In. Mercury	Lb. Vapor per Cu. Ft. Saturated	Cu.Ft. per Lb. Vapor Saturated	Lb. Vapor per Lb. Air Saturated
140	5.88	0.00814	122.8	0.153038
139	5.73	0.00795	125.8	0.148293
138	5.58	0.00776	128.9	0.143615
137	5.43	0.00757	132.1	0.139005
136	5.29	0.00739	135.4	0.134703
135	5.16	0.00721	138.7	0.130515
134	5.02	0.00703	142.2	0.126327
133	4.89	0.00686	145.8	0.122425
132	4.76	0.00669	149.4	0.118575
131	4.64	0.00653	153.2	0.114997
130	4.520	0.006370	157.1	0.111457
129	4.399	0.006207	161.1	0.107909
128	4.282	0.006052	165.3	0.104557
127	4.168	0.005900	169.6	0.101310
126	4.057	0.005751	173.9	0.098161
125	3.948	0.005605	178.4	0.095103
124	3.841	0.005462	183.1	0.092135
123	3.737	0.005323	187.9	0.089280
122	3.635	0.005187	192.8	0.086515
121	3.535	0.005054	197.9	0.083824
120	3.438	0.004924	203.1	0.081235
119	3.344	0.004796	208.5	0.078711
118	3.252	0.004671	214.1	0.076263
117	3.161	0.004548	219.9	0.073868
116	3.073	0.004429	225.8	0.071578
115	2.987	0.004312	231.9	0.069348
114	2.904	0.004198	238.2	0.067186
113	2.822	0.004087	244.7	0.065099
112	2.740	0.003978	251.4	0.063050
111	2.665	0.003871	258.3	0.061092
110	2.589	0.003766	265.5	0.059163
109	2.515	0.003664	272.9	0.057303
108	2.443	0.003565	280.5	0.055510
107	2.372	0.003469	288.3	0.053785
106	2.303	0.003374	296.4	0.052090
105	2.236	0.003282	304.7	0.050455
104	2.171	0.003192	313.3	0.048866
103	2.107	0.003104	322.2	0.047329
102	2.045	0.003017	331.5	0.045823
101	1.985	0.002933	341.0	0.044369
100	1.926	0.002851	360.8	0.042960
99	1.869	0.002771	360.9	0.041597
98	1.813	0.002693	371.4	0.040271
97	1.759	0.002617	382.2	0.038990
96	1.706	0.002542	393.4	0.037732
95	1.655	0.002469	405.0	0.036519
94	1.605	0.002398	417.0	0.035344
93	1.556	0.002329	429.4	0.034207
92	1.508	0.002261	442.2	0.033084
91	1.462	0.002195	455.5	0.032015
90	1.417	0.002131	469.3	0.030975
89	1.373	0.002068	483.6	0.029958
88	1.331	0.002007	498.4	0.028979
87	1.289	0.001947	513.7	0.028015
86	1.248	0.001889	529.5	0.027096
85	1.209	0.001832	545.9	0.026192
84	1.171	0.001777	562.9	0.025333
83	1.134	0.001723	580.5	0.024482
82	1.098	0.001670	598.7	0.023653
81	1.063	0.001619	617.5	0.022862
80	1.029	0.001570	637.0	0.022102
79	0.996	0.001523	657.0	0.021378
78	0.964	0.001477	677.0	0.020670
77	0.933	0.001433	698.0	0.020000
76	0.903	0.001389	720.0	0.019329
75	0.873	0.001346	743.0	0.018674
74	0.845	0.001304	767.0	0.018041
73	0.817	0.001263	792.0	0.017424
72	0.790	0.001224	817.0	0.016836
71	0.764	0.001186	843.0	0.016264
70	0.739	0.001148	871.0	0.015706
69	0.714	0.001112	899.0	0.015171
68	0.690	0.001077	928.0	0.014651
67	0.667	0.001043	953.0	0.014154
66	0.644	0.001009	991.0	0.013657
65	0.622	0.000977	1,024.0	0.013160
64	0.601	0.000946	1,058.0	0.012738
63	0.580	0.000915	1,093.0	0.012286
62	0.560	0.000885	1,130.0	0.011849
61	0.541	0.000856	1,168.0	0.011435
60	0.5220	0.000828	1,208.0	0.011028
59	0.5034	0.000801	1,249.0	0.010644
58	0.4856	0.000775	1,291.0	0.010267
57	0.4684	0.000749	1,335.0	0.009898
56	0.4518	0.000724	1,381.0	0.009544
55	0.4357	0.000700	1,430.0	0.009205
54	0.4201	0.000676	1,480.0	0.008866
53	0.4049	0.000653	1,532.0	0.008542
52	0.3903	0.000630	1,586.0	0.008226
51	0.3762	0.000608	1,643.0	0.007917
50	0.3625	0.000587	1,702.0	0.007623
49	0.3492	0.000567	1,763.0	0.007351
48	0.3363	0.000548	1,826.0	0.007088
47	0.3238	0.000529	1,892.0	0.006826
46	0.3118	0.000510	1,961.0	0.006565
45	0.3002	0.000492	2,023.0	0.006319
44	0.2890	0.000475	2,107.0	0.006086
43	0.2782	0.000458	2,185.0	0.005854
42	0.2677	0.000441	2,266.0	0.005623
41	0.2575	0.000425	2,350.0	0.005407
40	0.2477	0.000410	2,438.0	0.005204
39	0.2382	0.000395	2,530.0	0.005003
38	0.2290	0.000381	2,626.0	0.004814
37	0.2202	0.000367	2,725.0	0.004626
36	0.2117	0.000353	2,829.0	0.004439
35	0.2034	0.000340	2,938.0	0.004268
34	0.1955	0.000328	3,052.0	0.004090
33	0.1878	0.000316	3,170.0	0.003947
32	0.1804	0.000304	3,294.0	0.003788
31	0.1720	0.000289	3,460.0	0.003592
30	0.1640	0.000276	3,623.0	0.003424
29	0.1565	0.000265	3,774.0	0.003280
28	0.1495	0.000253	3,953.0	0.003124
27	0.1426	0.000242	4,132.0	0.002982
26	0.1362	0.000232	4,310.0	0.002852
25	0.1298	0.000222	4,504.0	0.002723
24	0.1239	0.000212	4,717.0	0.002594
23	0.1182	0.000203	4,926.0	0.002478
22	0.1127	0.000294	5,155.0	0.002358
21	0.1076	0.000185	5,405.0	0.002249
20	0.1026	0.000176	5,682.0	0.002134

bulb temperature of 50 deg. and leaves saturated at 100 deg. (the dry-bulb and wet-bulb thermometers both reading 100 deg.). How much more work could be done by the same quantity of air if it could be discharged from the kiln saturated at 120 deg.

From the chart it is found that the saturation temperature at entrance is 42 deg., and the table shows that there is 0.005623 lb. of vapor per pound of air at that temperature. The table also shows that saturated air at 100 deg. has 0.042960 lb. of vapor per pound of air. The difference between these two weights, or 0.037337, is the weight of vapor removed per pound of air supplied. If the same were discharged saturated at 120 deg. the weight of vapor per pound of air would be 0.081235 lb. and the weight removed 0.081235 — 0.005623 = 0.075612. The increase in capacity due to the change in condition of operation would be 0.038275 lb. of vapor per pound of air, or 103 per cent.

3. It is desired to maintain the air in a building at 70 deg. and 59 per cent. relative humidity. The ventilating apparatus draws cold air from the outside, warms and humidifies it, delivering it saturated from the humidifier. The temperature is then raised to 70 deg., and the air is delivered to the building. At what temperature must the saturated air leave the humidifier in order that the air when heated to 70 deg. shall have the required relative humidity?

The chart indicates that the saturation temperature corresponding to 70 deg. and 59 per cent. relative humidity is 55 deg. The saturated air leaving the humidifier must therefore be at this temperature in order to fulfill the conditions. If the air leaves the humidifier unsaturated, then the readings of the wet- and dry-bulb thermometers must be such that the saturation temperature is 55 deg.

4. The outside air has a dry-bulb temperature of 95 deg. and a wet-bulb temperature of 83 deg. It is desired to supply it to the building of example 3 under the conditions named there. How can it be done?

The chart indicates that the saturation temperature of the outside air is 79 deg.; or in other words, if the air were cooled, its relative humidity would rise to 100 per cent. before it reached the required temperature. Cooling the air below its saturation temperature results in depositing moisture upon the cooling surface and maintaining the air saturated. It will therefore be necessary to cool the air to 55 deg., which is the saturation temperature corresponding to the required conditions, and then heat it to 70 deg.

5. Air with a dry-bulb temperature of 72 deg. and a wet-bulb temperature of 60 deg. is being heated to 135 deg and forced into a drying kiln in which there is no other source of heat. What is the maximum amount of moisture that may be removed per pound of air? Under what conditions?

The saturation temperature corresponding to the given initial conditions is 52 deg. When the air is heated to 135 deg., the saturation temperature remains the same. The maximum amount of moisture will be removed if the air leaves saturated. Since all of the heat necessary for evaporation is being supplied by the air, the temperature at which the air will become saturated by passing over moist material will be the wet-bulb temperature corresponding to 135 deg. dry-bulb and 52 deg. saturation temperature. This is shown by the chart to be 79 deg. The weight of vapor per pound of air saturated at 79 deg. is 0.021378 lb. The weight of vapor per pound of air at the initial condition is shown to be 0.008226 lb. which corresponds to the saturation temperature of 52 deg. The weight of moisture removed per pound of air will therefore be the difference between 0.021378 and 0.008226, or 0.013152 lb. The discharge temperature will be 79 deg. Copies of this chart of approximately the size here used, as well as 24x36 in., may be had from the Columbia University Bookstore.

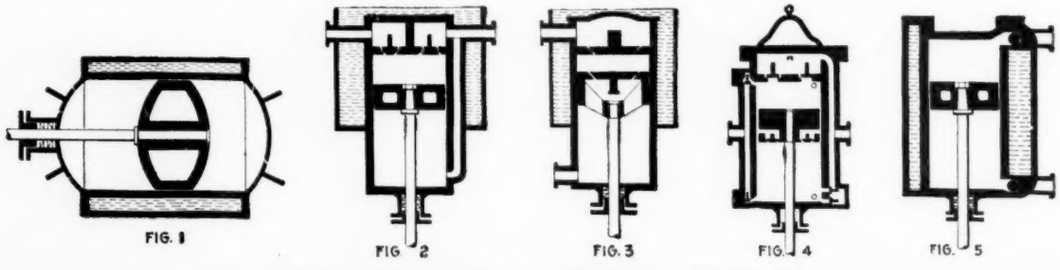
Diagrams of Some Types of Ammonia Compressors

By William Schliemann

Fig. 1 shows a wet, or humid, compressor; the valves are placed in the heads and no water jacket is required. Large clearance must be avoided because the liquid, which passes along with the gas or is squirted into the cylinder to take away the heat of compression by its evaporation, may not all evaporate. So if any liquid remains it will be evaporated on the return stroke and occupy valuable space, as the suction valve will not open until the pressure in the cylinder has been lowered below that of the back pressure in the suction pipe. But these machines are becoming obsolete, and modern compressors are provided with water jackets to take away the heat of compression.

Fig. 2 shows an early dry-gas compressor of the single-acting type. The valves are placed in the head. The suction inlet is arranged so that the incoming gas, which at times is mixed with liquid, is trapped through a channel in the bottom part of the cylinder. This trapped vapor and liquid is churned back and forth, but it also cools the piston and cylinder walls. The upper part of the compressor is cooled by water contained in a jacket.

A dry-gas compressor of the single-acting type, provided with a water jacket, is shown in Fig. 3. The dis-



DIAGRAMS OF TYPES OF AMMONIA COMPRESSORS

Fig. 1—Wet or humid compressor. Fig. 2—Early dry-gas machine. Fig. 3—Single-acting; valve in piston. Fig. 4—Double-acting, internally cooled machine. Fig. 5—Double-acting water-jacketed compressor

charge valve is placed in the head and the suction valve in the piston. These valves are of large dimensions, and the lift is therefore comparatively small, thereby reducing wear. The clearance is small, but can be adjusted by screwing the piston rod in or out of the crosshead. The suction inlet is at the bottom of the compressor, the discharge outlet at the top.

Fig. 4 shows an internally cooled compressor of the double-acting type, handling also a dry gas. This compressor has no water jacket, but the heat of compression is taken away by mineral oil pumped in or injected at the compression stroke of the compressor. This oil really serves three purposes: First, furnishing lubrication for the piston-rod, piston, and valves; secondly, absorbing the heat of compression; thirdly, filling up the clearance spaces. The suction valves are placed in the side at the top and bottom; the discharge valves are placed in the head at the top and also in the side at the bottom. There are a number of valves in the lower part of the piston, for relieving the compressor of oil and vapor when the piston reaches the extreme bottom end of its travel. The oil and vapor is discharged through these valves into the space left between the two parts of the double piston and from there through the bottom discharge valve.

A double-acting compressor with water-jacket is shown in Fig. 5. The valves are all placed in the sides; this construction requires large valve pockets, which add to the clearance and also to the safety of operation, as the valves cannot fall into the cylinder in case of breakage. The water jacket is effectively arranged. As the reader notices from the drawings, the valves of none of these compressors are mechanically operated.

Notes on Surface Condensers

By A. B. Clark

SYNOPSIS—Temperature head defined, heat transfer per square foot and the effect the velocity and temperature of the cooling water and the diameter of the tubes have upon the vacuum.

It has been said by some engineers that a surface condenser is only a box of tubes. To all outward appearances this is undoubtedly so, and in many cases it would seem that surface condensers have been designed on these lines. But these conditions cannot exist at the present day, when the highest possible vacuum is called for. To show just how far we can expect to go in this direction and to see what influences the vacuum produced are the objects of this article.

The question of the condensation of steam is one of heat transfer from the steam to the cooling water. Everyone knows that heat can flow only from a hot body to a cooler one. It is therefore obvious that the cooling water must be colder than the steam, but how much colder the water must be to transmit a given quantity of heat or, what is the same thing, to condense a given quantity of steam, is not so obvious. This difference in temperature is called temperature head. Just as it is necessary to have a difference in head for water to flow, so there must be a temperature head for heat to flow.

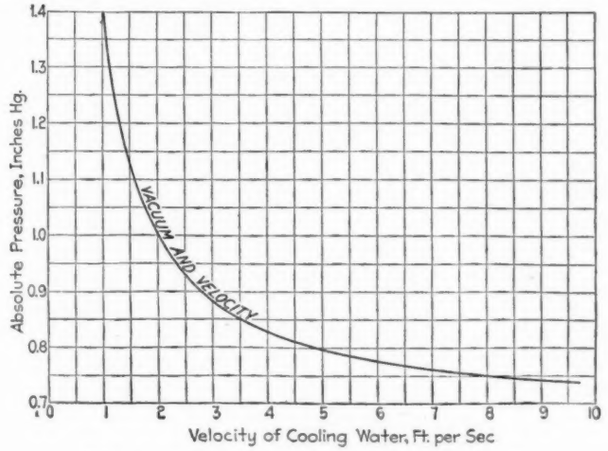


FIG. 1. VACUUM AND VELOCITY CURVE

Vacuum obtained with cooling water averaging 60 deg. F. at various velocities; condensing 7.5 lb. of steam per sq.ft.

The heat that it will be necessary to extract per pound of steam condensed is about 930 B.t.u. in the case of large modern steam turbines; therefore if the condenser is to condense 7 lb. of steam per square foot of surface per hour, the quantity of heat to be transmitted will be 6,510 B.t.u. per sq.ft. per hr. To transmit this heat from the steam to the inside wall of the tube requires a temperature head or difference of 7.03 deg. F., or 1.08 deg. F. per 1,000 B.t.u. transmitted per square foot per hour. This figure is practically constant for all condenser conditions. The next thing is to transmit the heat from the tube to the cooling water. Here there are two variables that effect this heat transfer—the velocity of the cooling water through the tube and its temperature. The velocity will be considered first, assuming the average temperature constant at 60 deg. F. The average temperature must be considered, as the temperature of the cooling water increases as it flows through the tube. If the water velocity is 3 ft. per sec., the temperature head will be 7.15 deg. F., but if the water velocity is increased to 5 ft. per sec., the temperature head is only 4.3 deg. F. This clearly shows the advantage due to the increased velocity. The total temperature head is therefore $7.15 + 7.03 = 14.18$ deg. F. for the 3 ft. per sec. and $7.03 + 4.3 = 11.33$ deg. F. for the 5 ft. per sec. As the average cooling-water

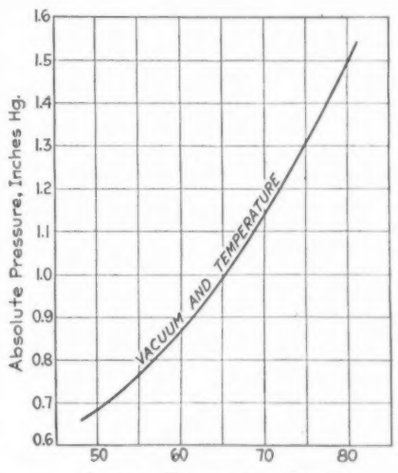
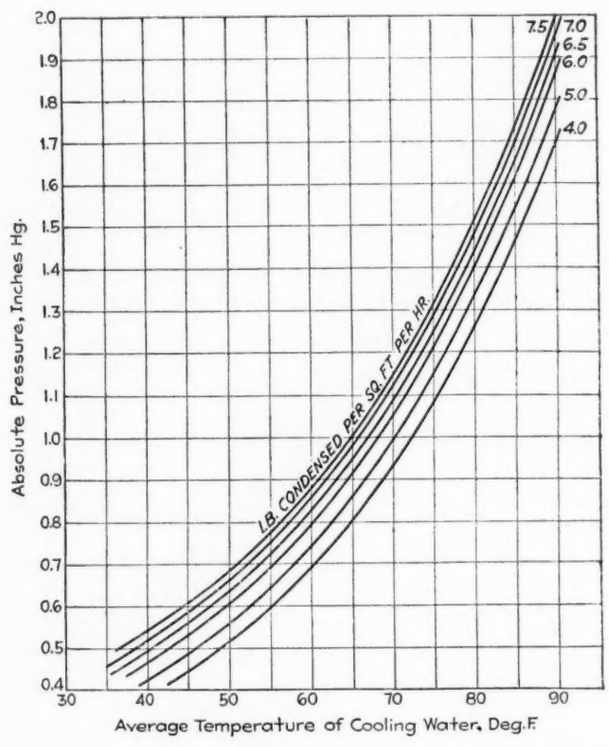
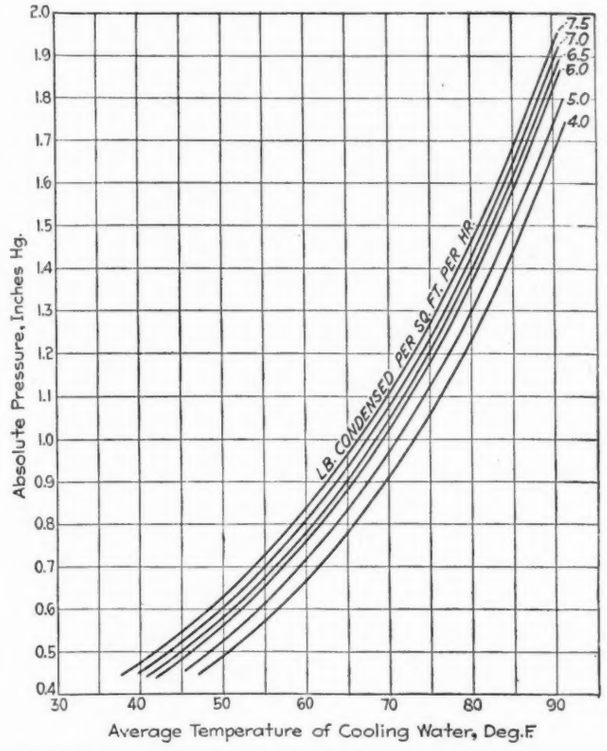


FIG. 2. VACUUM AND TEMPERATURE CURVE

Vacuum obtained with cooling water velocity of 3 ft. per sec.; condensing 7.5 lb. of steam per square foot per hour





FIGS. 3 AND 4. MAXIMUM VACUUMS FROM AIR-FREE CONDENSER

Fig. 3—Water velocity through tube 3 ft. per sec.; different rate of condensation; standard 1-in. tubes No. 18 gage.
Fig. 4—Water velocity 4 ft. per sec.; other conditions the same as for Fig. 3

temperature is 60 deg. F., the temperature of the steam is 60 + 14.18 = 74.18 deg. F. and 71.33 deg. F., respectively, corresponding to vacuums of 0.85 and 0.77 in. of mercury absolute. Fig. 1 shows this on a curve, but calculated for a greater heat transfer. It should be noticed here that there is not much to be gained by

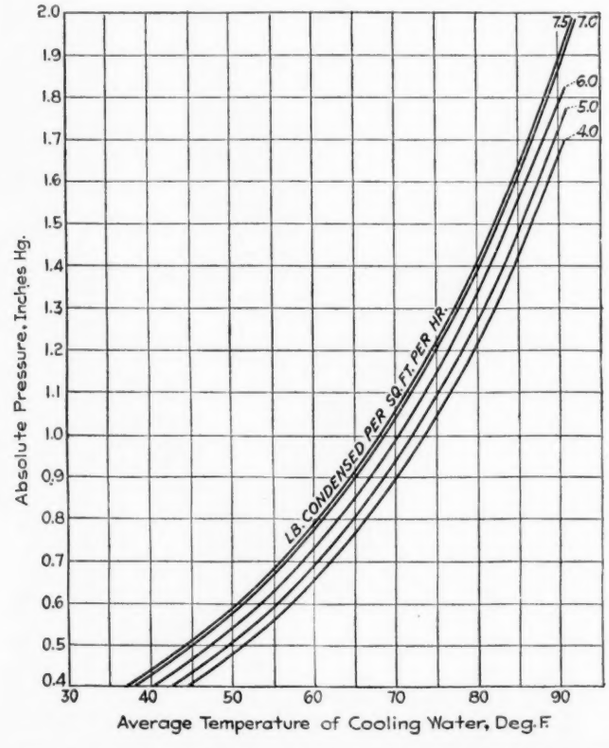


FIG. 5. MAXIMUM VACUUM WITH WATER VELOCITY OF 5 FT. PER SEC.; OTHER CONDITIONS THE SAME

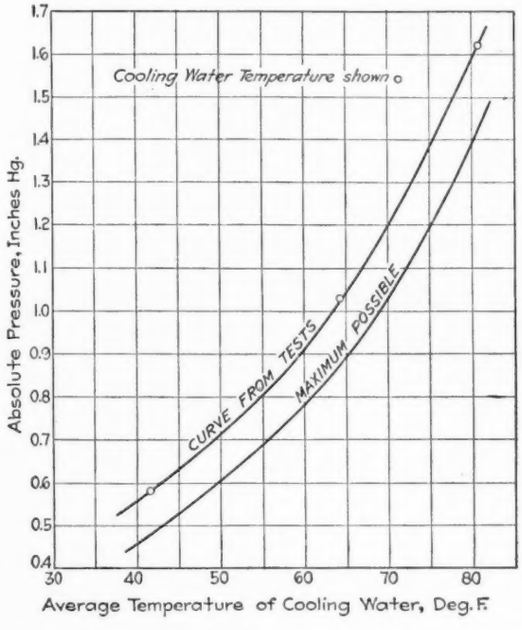


FIG. 6. VACUUM OBTAINED AND MAXIMUM POSSIBLE When condensing 6.8 lb. of steam per sq.ft. per hr. with different average temperatures of cooling water

increasing the water velocity above 5 or 6 ft. per sec. To return to the effect of temperature, the water velocity will be assumed constant at 3 ft. per sec., and the average temperature varied to 50 and 70 deg. F. Now at 50 deg. F. the temperature head due to velocity and temperature is 10.2 deg. F., and at 70 deg. F. it is 5.4 deg. F. To each must be added the 7.03 deg. F. to get the total temperature head, which gives 7.23 and 11.43 deg. F. respectively. The temperatures of the steam are

therefore 50 + 17.23 = 67.23 deg. F. and 70 + 11.43 = 81.43 deg. F., which correspond to absolute pressures of 0.67 and 1.08 in. of mercury. Fig. 2 shows a graph of this.

Figs. 3, 4 and 5 have been calculated to cover all condenser conditions that are likely to occur in practice. The curves really explain themselves, but as an instance, suppose the cooling water enters the condenser at 60 deg. F. and leaves at 74 deg. F. The average temperature is 67 deg. F. In making the charts it was considered sufficiently accurate to take one-half of the sum of the inlet and outlet temperatures as the mean temperature. If 6 lb. of steam is condensed per square foot per hour, the vacuum is 0.97 in. abs. with a water velocity of 3 ft. per sec., 0.84 in. at 4 ft. per sec. and 0.9 in. at 5 ft. per sec.

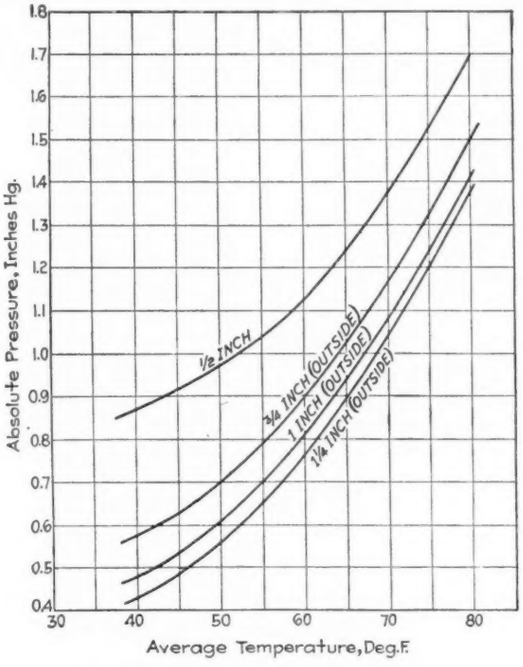


FIG. 7. EFFECT OF TUBE DIAMETER ON VACUUM
Velocity of water, 3 ft. per sec.; condensing about 6.5 lb. per sq.ft. per hr.

These curves give the maximum vacuum it is possible to get under the conditions. In practice condensers always fall short of these results.

Fig. 6 has been drawn to show how close a reasonably clean condenser will approach these figures. The difference, it will be seen, varies from 0.1 to 0.2 in. No doubt if this condenser was boiled out with soda a better agreement could be obtained, but a slight scale or mud on the tubes will require a much greater temperature head.

It will be seen that the curves drawn are for standard 1-in. tubes, No. 18 gage. As this is the most usual size of tube at the present day, it is not necessary to consider other sizes, except to show their influence on the vacuum produced. Fig. 7 has been calculated to show this graphically for a water velocity of 3 ft. per sec. and condensing 6.5 lb. of steam per square foot per hour. Four sizes of tubes have been considered. It will be seen that the gain from ½- to ¾-in. tubes is considerable, and there is an appreciable gain as between tubes ¾ and 1 in. in diameter. A 1¼-in. tube does not show much advantage over the 1-in. size, and it is considered that the latter is about the best, taking everything into consideration.

The question of air leakage is not considered, as this can be reduced to a small amount, say 1 or 2 cu. ft. of free air per minute at standard temperature and pressure. Besides, the modern air pump is being constantly improved so that considerable air leakage can be handled at very low absolute pressures.

The curves shown give a complete theory for the surface condenser. The writer has used them for years when making an analysis of condenser tests and has always found them to be of the greatest assistance. As already pointed out, condensers never quite come up to the maximum possible conditions as set down in Figs. 3, 4 and 5, but modern condensers should not differ by more than 0.3 in. from them. When the temperature of the condensate is practically equal to that corresponding to the vacuum at that point, the agreement has been found to be within 0.1 in.

Card-Indexing Plant Employees

By H. S. Knowlton

A card-index or loose-leaf record of every employee of a power plant should form a part of the "chief's" records. The entries on the cards will naturally vary according to the local engineer's requirements, but they will normally contain such points as the age, address, previous experience, present salary or wages, dates and compensation on different work in the history of the plant, and possibly some hints as to the employee's special fitness for certain kinds of service. Any notable achievements might properly be recorded, also the quickest means of reaching the employee when off duty, and other data of this kind.

In a small plant the chief engineer often considers such a record unnecessary; he knows every man by his first name and more or less of his previous experience and present capabilities. Even the small plant, however, should possess these data, and their value in future years should never be measured by their apparent needlessness, when the plant is run by a staff of a few men who have long been personal friends through association. Accurate and immediate information is often worth the trouble of maintaining a card index and where it is necessary to know a man's record it is much more accurate than one's memory.

Calculating Heat Value of Coal

The formula most commonly used for calculating the heat value of coal from its analysis is that of Dulong, revised by adding 40 B.t.u. for each per cent. of sulphur present in the coal, and is as follows:

$$\text{B.t.u.} = 146C + 620\left(H - \frac{O}{8}\right) + 40S$$

In this formula, C is the percentage of fixed carbon, H the percentage of hydrogen, O that of oxygen and S that of sulphur in the coal, as determined by its ultimate analysis. The heat thus calculated is the heat (B.t.u.) per pound of coal and must be divided by the percentage of combustible matter expressed decimally, in order to find the heat per pound of combustible. For example, the ultimate analysis of a sample of coal shows: Carbon, 76.48 per cent.; hydrogen, 4.29; oxygen, 4.34; nitrogen, 1.22; sulphur, 2.42; ash, 11.25. The heat value per pound of coal, as calculated by the Dulong formula, is

$$\text{B.t.u.} = 146\,(76.48) + 620\left(4.29 - \frac{4.34}{8}\right) + 40\,(2.42) = 13{,}587$$

The heat determined by experiment, is 13,469 B.t.u. The percentage of combustible in this coal is the sum of the percentages of fixed carbon and volatile matter taken, as 85.93 per cent. The heat value per pound of combustible, in this case, is 13,587 ÷ 0.8593 = 15,811 B.t.u.—"Coal Age."

Ring Fire and Flashing

By Gordon Fox

SYNOPSIS—The author distinguishes between ring fire and flashing, enumerates the causes leading up to each and points out how to avoid them.

Every operator of direct-current machines is familiar with the sparks or rings of fire that often travel along the surface of a commutator, encircling it wholly or in part, but some, perhaps, do not know the causes and effects of this condition.

Ring fire may be differentiated into two classes, which are discernible by the color of the flame. Ordinary ring fire, such as may be present to some extent upon most machines, is of a reddish color. Ring fire due to a defective armature is bluish-green and more intense.

All ring fire is primarily due to slight arcing across mica segments from one commutator bar to another. This is augmented by the presence of foreign material embedded in or adhering to the surface of the mica segments. The leakage of current through these particles causes them to become incandescent, and the rotation makes them appear as rings of fire. Any conducting material upon or in the mica will cause this action. Filings or other dirt from surroundings may locate in the mica. More commonly, the carbon from the brushes or particles of copper from a newly turned commutator lodge in the insulation. Graphite brushes have a lubricating effect on the commutator, coating it with a thin glaze of semiconducting nature. Ring fire is more prevalent with graphite brushes than with harder carbon brushes, other things being equal. The use of paraffin wax as a lubricant often leads to ring fire, particularly if the commutator is cool. The wax then gums and the sticky surface readily gathers and retains dirt and foreign matter. Oil gradually disintegrates many commutators, largely because of the effects of ring fire. The oil tends to burn and carbonize, causing a black deposit in the mica. It also tends to dissolve out the binding material in the mica bond. The accumulation of carbon from the oil and that from the brushes, adhering because of the oil, lowers the resistance between bars, encourages leakage and gives rise to ring fire. The incandescent condition of the material causes burning so that pitting of the mica soon sets in. Localized eating away of the mica can nearly always be traced to a series of events as described.

Tendencies of Undercut Commutators

Undercut commutators are likely to show ring fire, as particles of conducting matter gather in the slots and cause leakage. Undercut commutators should not be lubricated with oil, as the latter will gum and aid the collection of dirt in the slots. Machines having high peripheral commutator speeds will keep the slots clear through centrifugal action, but slower-speed machines may require the occasional application of a stiff brush to prevent such accumulations.

The thickness of the mica segments has some bearing upon the tendencies to carry over from bar to bar. Most machines use mica about $\frac{1}{32}$ in. thick. Narrower mica than this will render a machine particularly susceptible to ring fire, while thicker mica is usually objectionable since greater abrasion is then required of the brushes to prevent "high mica."

The leakage between commutator segments naturally depends upon the voltage across the insulating barrier. A leakage will occur, no matter how low the voltage difference, but sufficient current flow to cause incandescence and to show as ring fire will take place only under appreciable voltages. The voltage between two adjacent segments continually undergoes changes in value. When a coil is under the main poles and in a strong field, there is considerable voltage generated within it, so that the potential difference between the two bars connected to the ends of the coil will be high; but when it is in the neutral zone, the voltage between segments will be nearly zero. The variation in values of voltage per coil or voltage between adjacent bars corresponds to the intensity of the field magnetism.

Point of Greatest Commutator Leakage

The greatest commutator leakage occurs about halfway between brush studs and is almost nil at the neutral points. Ring fire is usually seen to be more severe between brushes, the particles becoming incandescent in the midway zone or thereabouts. The sparks are then carried along in the direction of rotation toward the following brush stud.

An exact value of potential difference between bars which will cause ring fire cannot be stated, since a number of modifying factors exist. In large machines a maximum, or peak, value of 25 volts per bar will be likely to start this action. Medium-sized machines may have 30 volts per bar at the peaks, while very small machines may have potential differences as high as 50 volts without undue leakage or burning. The permissible values depend upon the capacity and speed of the machine as well as the type of brushes used and operating conditions. The larger the machine the greater its current capacity and the lower its armature resistance; hence more leakage is likely to occur across a given insulation resistance. Small machines have comparatively high internal resistance; consequently a higher voltage is required to force sufficient current through the coil and segment circuit to cause incandescence.

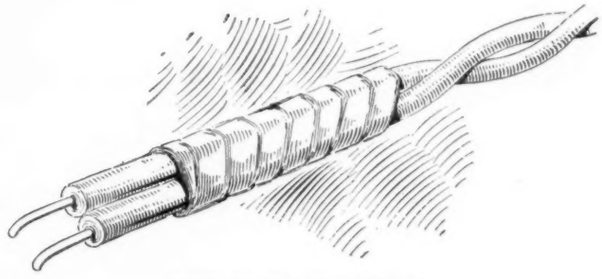
Ring Fire Affected by Commutator Speed

The speed of a machine or, rather, the peripheral speed of the commutator, has a bearing on the ring-fire tendency. A definite, though brief, period of time is required to bring the material bridging the mica up to an incandescent condition. If the segments do not remain in the zone of large potential difference sufficiently long, no opportunity is afforded for the leakage to assume serious proportions. It might be of interest in some instances to know how great values the potential differences between the bars of a machine attain, where the peak zone occurs, and how great is its breadth. If a voltmeter is at hand, all that is necessary is to provide a pair of exploring terminals arranged to bridge from one commutator bar to the next, as shown in the illustration. Starting at one brush stud, the terminals may be slowly moved around

the commutator, noting the voltage values for different positions. By plotting these values a field-form curve is obtained, showing the points desired.

Another method of measuring values for the field-form curve, also employing a voltmeter, can be carried out by connecting one meter terminal to one brush stud, the other terminal being connected to a stiff wire that can be held upon the commutator. This free terminal is first placed close to the stud to which the other lead is connected, and a reading is taken. Then the free terminal is moved slowly away along the commutator surface, readings being taken for equal increments of movement until a brush span has been covered. Subtracting each reading from the next, the increments of voltage per unit of pole arc are found.

The kind of ring fire due to an open circuit or poor connection in the armature is fairly distinctive, being more intense, of a bluish-green color and sustained often completely around the commutator rather than appearing only in zones. The cause of this burning is also leakage between segments. It is abnormally severe because the



EXPLORING TERMINALS

open circuit causes a high potential difference between the segments connected to the defective coil. The leakage current is sufficient to heat the edges of the copper segments to a temperature where minute particles will be melted off and volatilized. This vaporized copper gives the flame its characteristic blue-green color. A poor joint between a commutator riser and an armature coil may cause a condition similar to an open circuit, but to a modified degree. The voltage between the connected bars will be increased and the tendency to leakage thereby encouraged. Open circuits can usually be located with the armature stationary because the commutator bars connected thereto are pitted on their edges by the arcing and vaporization of the copper.

Ring fire in itself is not necessarily harmful. Many machines giving very satisfactory service display a tendency to this action. If the occurrence is severe and continued, gradual disintegration of the mica is likely. The leakage may also warm up the commutator slightly, although the writer has known of but one commutator that ran hot through excessive leakage through the mica segments. Severe ring fire may lead to flashing, other conditions being favorable.

Flashing in direct-current machines may arise from a variety of causes. All flashes, however, require the presence of vaporized copper, which forms a conducting arc bridging between parts of differing potential. Whatever sets up the initial arcing sufficiently to vaporize the copper is the basic cause of the flash-over.

Railway and haulage motors and others subjected to severe vibration may suffer from flashes arising through poor brush contact. Sufficient separation between the commutator and brushes may occur to draw an arc, volatilize the copper and precipitate a flash-over. Other causes of severe sparking, including high mica or a rough commutator, may lead to the same difficulty.

Ring fire, when severe, not infrequently causes flashing. Leakage may be set up between two adjacent bars sufficient to cause incandescence and the vaporizing of a minute amount of copper. The gas thus formed may span to a third bar so that a higher potential difference becomes involved. The arc may thus bridge a number of bars, become aggravated and lead to a flash. This tendency is particularly strong in machines having narrow, crowded bars with high peak values of volts per bar. The potential difference per inch of commutator surface is then high and the arcing possibilities are more prevalent.

Ordinary overloads do not often lead to flashing, but excessive overloads, such as short-circuits on the line, may easily do so. The armature current, rising to several times normal value, distorts the field, shifts the neutral and causes large short-circuit currents to flow through the brushes. The extreme load thus imposed at the brush tips causes vicious arcing. If the resulting copper vapor reaches to any neighboring parts of opposite polarity a flash-over is probable. Suddenly applied overloads are more likely to cause flashes than are heavy loads gradually applied.

Flash-overs are sometimes attributed to the sudden relief from load caused by the opening of circuit-breakers. Then, often an arcing "short" on the line causes a rapid rise in current to a value sufficient to cause severe sparking, which may lead to a flash-over in the brief time interval required for the breaker mechanism to operate. Sometimes a temporary neutral shift may cause the action. Sudden change from overload to no-load conditions may involve almost instant drop in armature magnetization with less rapid falling off of main field or interpole effect, involving a temporarily unbalanced condition.

The proximity of parts of one potential to points of opposite or different potential subject to sparking encourages flashing. Thus a brushholder design or adjustment which brings any overhanging part very near the commutator is imperfect. For like reason it is well for brushes to be located in front of their studs so that arcs arising at the brushes will be carried into the brush rigging of like polarity rather than that of opposite polarity.

Flashing Caused by Sudden Interruptions

Sudden interruptions of the circuit may cause flashing in some instances. Shunt motors having the brushes widely shifted to handle heavy loads may spark viciously and flash if the load is quickly removed. Also the sudden drop in magnetism within the armature causes a discharge due to self-induction, which may start a flash if the machine is a sensitive one. Interpoles may give rise to flashing through sudden interruptions of load. The armature magnetization falling off more rapidly than that of the interpole shifts the neutral temporarily and places the commutated coils in a zone of overstrong interpole flux; the brushes then arc violently for an instant, and a flash may ensue if the arc vapor bridges to any near-by point of differing potential. This action was once impressed upon the writer while testing an interpole motor. To determine the proper interpole strength the motor was

run as a simple shunt machine, the interpole being separately excited. It was attempted to shut down the motor by merely pulling the line switch, opening the circuit feeding the armature and shunt field coils, the interpole windings being left excited. The inertia of the armature and that of the driven machine caused rotation to continue. The motor now acted as a generator, the interpoles acting as main fields. The brushes were obviously in the position of greatest voltage since the now existing neutral was displaced 90 electrical degrees from its regular position. Violent and repeated flashes ensued, the jolts almost jerking the motor from its base.

Returning to the action of interpole motors under sudden-load changes in ordinary operation, it may be seen why german silver adjusting shunts, particularly if non-inductively wound, may lead to difficulties. A local circuit is formed through the interpole winding and around the shunt. This acts in the same way as a short-circuited damping winding about the interpole iron so that the magnetism does not readjust itself quickly to changes of load. The fact that armatures are composed of laminations, whereas interpoles are often solid, also encourages the lag of the interpole so that under sudden changes in load the proper relative values are not maintained.

Both motors and generators are subject to flashing, although the originating causes differ somewhat. There is a little greater likelihood of a motor flashing over, because of sparking under the brushes; this is due to the field form. In a motor the maximum voltage between bars, or the peak of the field-form curve, occurs near the trailing edge of the brush, whereas in a generator the shifting is of opposite effect. The proximity of the zone of high voltage between segments in a motor to the trailing edge of the brush, which is the point of greatest sparking, makes it easy for the sparks to carry over and aid flashing across the segments in the peak of the field.

Lodge-Room Engineering--II

By W. O. Rogers

SYNOPSIS—Casey relates how an injector failed to operate and wants to know why a hole in the suction pipe could prevent its picking up. The discussion that followed brought out the reason why.

The next meeting night, the president, who evidently had a grouch, brought the members to order with so much vim that he bit through the stem of his pipe, the falling ashes from which were scattered over his new checked trousers, much to his disgust. After the business of the evening had been disposed of, Casey, the fireman, rose and addressed the chair, saying:

"Misther Presidint: Phoy do an injecthor refuse to operate whin you wants it to wourk? Can anywan of th' bunch tell me that?"

"What was the matter with it," asked Gus Semple, the oiler, with a wink at "Dusty" Miller, from the end of the room.

"Damnfino," answered Casey. " 'Dad' came out and says he, 'Mike, thry th' injecthor.' I thrid her and th' divil a bit would it inject, but made a spittin' and splashin' just as if it had th' colic. 'Dad' said th' suction poipe had a hole rusted in it, but divil a bit do Oi see phat that has to do with th' throuble."

"Mister President: For the benefit of Casey or any other jay, I want to say that it's got a whole lot to do with it," volunteered Joe Sumers, who was engaged in whittling a toothpick, New England style. "The hole stops the water from coming up in the suction pipe above the level of the supply."

"Domned 'f Oi see how a little hole is agoin' to sthop wather from comin' up in a poipe," rejoined Casey, glaring at Sumers. "That makes me think, How th' divil does Muldoon th' saloon kaper bring th' beer up from th' cellar int' a schooner?"

"I don't know much about the beer," replied Sumers, who had remained standing, "but the principle is the same, for air pressure forces the beer from a barrel into a glass, and air pressure causes water in a pond or well to rise into the suction chamber of a pump. It is simply a difference of pressure on the liquid outside and inside of the pipe.

"The beer is forced up in the pipe because a greater air pressure has been created in the keg than exists at the faucet outlet. With a pump the air pressure on the surface of a pond of water is 14.7 lb. per sq.in., but in the suction chamber of a pump the pressure is less than atmospheric pressure, or a partial vacuum, which would average about 10 in."

"Well, how th' divil does th' vackum get in th' pump? Oi can fire coal to bate th' divil, but Oi throw up me hands when it comes ter handlin' nothin' loik what they say a vackum is;" and Casey's bewildered look increased in intensity at the laugh that followed his comment.

"Easiest thing in the world," answered Sumers, who still held the floor. "When the plunger of a pump moves toward the opposite end of the cylinder from which it starts, a space is left to be filled with either air or water. If air can get into the suction chamber in sufficient quantities to equal the outside pressure, the vacuum is destroyed, and then as the water in the bottom end of the suction pipe has the same air pressure on its surface as the water on the outside, there is no pressure tending to force the water up into the suction chamber.

"It won't make any difference if the pump is started and run at high speed, the space left in each end of the water cylinder will be filled with air just the same coming in at the leak, instead of water from the pond."

"Oi'll not dispute yer wourd," replied Casey, "but tell me wan thing. Phat th' divil has a pump got to do wid an injecthor?"

"Casey, you will address the chair when speaking to a member," admonished the president with the grouch.

"Mr. President: I would reply to Casey that a pump has nothing at all to do with an injector," said Sumers, catering to the chair's dignity, "but a leak in the suction pipe on an injector will destroy the partial vacuum formed by the condensing steam just as easily as it will destroy the vacuum formed by the plunger of a pump moving in a cylinder."

"Misther Presidint: That's all roight, but phoy didn't th' domned injecthor wourk?" demanded Casey.

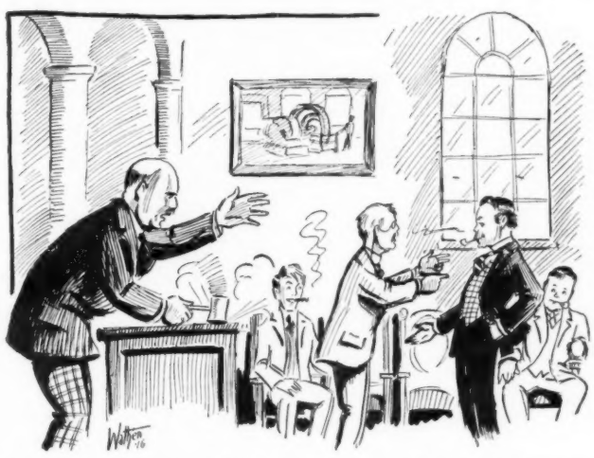
"Because the hole in the pipe admitted air, which entered the injector tube in place of water, and as the steam failed to condense, no vacuum was formed or not enough to permit the air on the surface of the water in the pond to force it up into the injector. The reason the injector made the noise it did was because the air leak was not enough to prevent some water from coming up into the injector, but not enough to furnish a full supply, consequently the injector broke, as it is called."

"Mr. President: I would like to inquire why Casey happened to try the injector?" questioned Roy Winters.

"No happen about it," answered Casey neglecting the chair. "We thry things out in our plant wanet a wake, whether they nade it or not, jist to see if the domn things will work."

"Makes a lot of bother, don't it?" commented "Dusty" Miller.

"Mr. President: Bother shouldn't be considered in a steam plant when it stands in th' way of continuous operation," said "Dad" Johnson, upon being recognized by the president. "It isn't as much bother to try th' different stand-by devices as it would be to have th' regular



"OI'LL NOT DISPUTE YER WOURD, BUT PHAT TH' DIVIL'S A PUMP GOT TO DO WID AN INJECTHOR?"

machine fail and find that th' extra machine had gotten out of order. Take th' injector, for instance. Th' last time it was tried it worked all right, but this morning it failed to pick up water. Suppose th' biler-feed pump had broken down. Th' injector would have been tried, and as it wouldn't work th' probabilities are that th' plant would have been shut down. By means of th' weekly trial, th' defect was discovered, and it was remedied this afternoon."

"How much would a shutdown have cost?" asked Myers, who was seated next to "Dad" and always wanted to know the cost of things.

"Well," answered "Dad," "not being th' head bookkeeper, I can't tell, but you can figure on th' wages of 1,000 men and women as ranging from $2 to $5 a day, and their loss would be in th' neighborhood of $1,500 in wages for th' afternoon alone. There would be added to that amount th' profit on th' goods that would be turned out during th' afternoon. So you see a simple thing like a hole in th' suction pipe of an injector might result in quite a loss."

"That's pretty nigh right, by Heck!" commented Joe Sumers. "It's a good deal like a rotten tooth—the hole may be small, but cold air agin the nerve kicks up lots of trouble."

"Takes less than a hole in a suction pipe to stop some injectors. I've seen 'em when they wouldn't work with a tight pipe," remarked Jake Grumbling from across the room, regardless of the pounding of the president's gavel.

"What was the matter with them, Jake?" asked Roy Winters, amid the tumult.

"Never bothered to find out," answered Jake. "I just shipped 'em to the maker, let 'em fix 'em up and the company footed the bill."

"That's hardly the way to get the confidence of your employer," said "Dad." "That might have been all right years ago when an engineer wasn't supposed to know anything, but today th' engineer don't feel as if he was doing justice to himself unless he uses every method available in tryin' to determine th' cause of whatever th' trouble may be. I hardly think there are many engineers who would follow Jake's method of disposing of his troubles," and "Dad" looked at Jake with a hurt, half-pitying expression.

"Jake niver did a job if he could get some other duffer t' do it for him," commented Casey, as he scratched a match on the seat of his trousers and deftly lit his pipe by covering it with both hands.

Jake Expresses His Views

"I don't see as it ever made any difference to me," growled Jake. "I have heard you fellers talk a lot in these meetings about saving for the company and working overtime and all that, just for the sake of doing right and going to bed with an easy conscience, but I don't see but that I have got just as good a steam plant to run as the rest of the bunch with the exception of "Dad," and when I'm as old as he is, I'll bet a nickel I'll have one just as good. This—"

"But Jake," interrupted Semple.

"Shut up," snapped Jake, amid the shouting of the president for order. "Wait until I'm done and don't butt in. As I was saying, this breaking your back doing things you'r ain't paid for don't amount to much. It comes pretty near being a case of the more you do the more the company you are working for expects you to do. If this wasn't so, do you suppose over half of the engineers in the United States would be working for from $12 to $16 a week, and not only that, but running to the beck and call of this and that one out in the shop? Not on your life. I cut that out long ago, and I git more money a week than the average engineer. All I have to do is to stay in my own boiler and engine rooms, and it don't make a bit of difference to me if every belt in the shop breaks or the bearings all get red-hot."

"Hear th' champion of wimen rights sthick up for his own," chuckled Casey at Jake's evidence of warmth.

"An engineer ain't got any business out of his steam plant, and when all engine runners git so they have enough backbone to tell the boss they won't go into the office and scrub the windows or into the shop and lace belts, line up shafting and set new machines, then he will be looked on as something more than a common lumper, which is a little lower than a dago. Most engineers ain't engineers, they're just laborers with a license to start and stop one engine."

"Oh, come off," exclaimed Roy Winter, "engineering is a profession."

"Profession nothing," retorted Jake. "Starting and stopping an engine don't represent the duties of a professional man, and squirting oil and wheeling coal and ashes don't look like professional duties to me. All of this talk about the average engineer being a professional man is punk."

"Punk or pumpkins, 'tis all th' same to me," interposed Casey, "Phat Oi wants to know is why Jake's injecthor wouldn't wourk."

"Probably in Jake's case," answered "Dusty" Miller, "the tubes got scaled up, and although an injector might pick up water owing to some obstruction in the forcing tube it wouldn't do the work of putting it into a boiler. In most cases an injector trouble can be found right in the forcing tube. It first comes to notice when trouble is experienced in picking up and forcing the water. For instance, it is found that care must be used in starting the injector, for it will fall down if steam is admitted too fast. About the same time it will be noticed that the injector is not throwing as much water as it should, and then it will go to breaking for no apparent reason."

"And yer mane to say 'twas the scale in th' thubes?" inquired Casey. "If that's th' case, phwot yer goin' to do?"

"Take the tubes out and soak them in a solution of one part muriatic acid to ten parts of water, and when the scale has become soft, it can be washed out without any trouble."

"There are plenty of other reasons why an injector won't work," supplanted "Dad." "A high lift is one, a long suction with a lot of bends is another, wet steam is another cause, and still others are a pipe partly filled with sediment and also wrong connections. These, with what has already been mentioned, will cover most troubles met with in injector practice."

"Everywan has throubles of his own," said Casey, beginning to hum the words to the air of a popular tune, as the president brought his gavel down with a startling bang and declared the meeting adjourned; much to the disgust of "Grumps," who had attempted to get the floor.

Effect of the Load Factor on Investment

In his presidential address to the Institution of Engineers and Shipbuilders in Scotland, W. W. Lackie said that 18 years ago little attention was paid to the steam consumption of plant purchased. The chief consideration was price. This was due to the fact that in those days electric lighting was the chief use to which the supply was put. The load factor was between 10 and 15 per cent., or in other words, the output corresponded to from 2½ to 3½ hours per day of the maximum load on the plant. Interest, sinking fund and depreciation represented by far the largest charge against revenue in the annual balance sheet. The coal bill represented only 10 per cent. of the revenue.

The load factor now obtained in most large stations, owing to the use of electrical energy for power purposes, has been raised to 25 and 30 per cent., and we look forward to a load factor of 50 per cent. The price of plant is, therefore, not now the first consideration, and steam consumption has to be seriously taken into account.

JUST FOR FUN

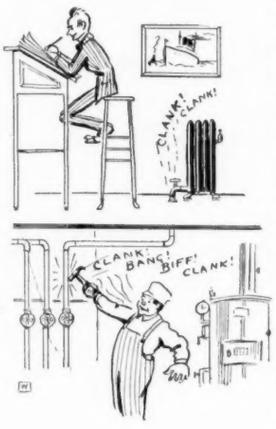
Reporter on the Job

A reporter on a local newspaper published the following regarding the cause of a recent boiler explosion:

The explosion was caused by the fireman letting the water get too low in the boiler. The pump was working badly. It was finally started, and the rush of cold water on the red-hot and bare pipes ignited the gas that accumulated from the metal and caused the boiler to explode. Wood, however, was burned in the boiler, but the gas was caused by the overheating of the pipes, and then turning the cold water into them.

A Substitute for Heat

A telephone call from the office requested the engineer to turn on the steam. Instead of explaining to the bookkeeper, who had about an hour's work to do, that there was no steam, the engineer hit the pipes a few discordant raps with a wrench, making a noise like coming heat. The trick must have worked, because nothing more was heard from his "Royal Highness."—Charles Haeusser, Albany, N. Y.



Fooling the Public

A backwoods engineer had charge of a small engine and dynamo, and the latter was sparking badly at the commutator. On being asked why he let the machine spark, he said: "Oh, that's all right! I let her spark a little so people will know she's running."—Frank Gartmann, Milwaukee, Wis.

Made a Record Test

One veteran water-works contractor in the days of coal-duty guarantees, before starting a test filled the space back of the boiler bridge-wall with coke, a gashouse being conveniently near. It is needless to say that the test was a record breaker and fully met the guarantees—in fact, the safety valve kept popping off for a day after the test.

Did Not Use Drift Pins

Consistency is a virtue, but it is not always regarded as such. It is easy to preach one thing and practice another, as is emphasized by a large boiler works that used to advertise, "We use no drifts in our shop." When the company went out of business the auctioneer offered five tons of drift pins for sale in one lot.

Honesty—— Oh, what's the use?

Pumping Nothing

A student, in answering a number of examination questions, described a vacuum pump as being one for pumping vacuums. He also appended, "Inasmuch as a vacuum is nothing, a vacuum pump would have nothing to do, and there can be no reason for having such a thing in a power plant. I therefore understand the query to be a catch question."—S. F. Wilson, New York City.

Editorials

Status of the Economizer

Engineers are frequently confronted with the question, "Shall we install a feed-water economizer?" both when designing new plants and when considering plans for overhauling or improving the efficiency of old stations. It is therefore pertinent to inquire into the present status of the economizer and note whether its manufacturers have improved this equipment in a manner commensurate with the advances made in other power-plant equipment.

The three main considerations governing the decision to install or omit an economizer may be stated as follows: First and primarily the cost of fuel; second, maintenance and operation charges; third, first cost and available space.

The first of these is by far the most important, for as the price of fuel advances, the value of a small percentage of saving in heat quantities increases rapidly. Hence most uptodate plants in localities where the price of coal is high are now equipped with economizers, and their operation is closely watched so as to obtain the highest efficiency. But with the prospect of continually increasing coal costs, designers of large stations, even in localities where coal is not considered high-priced, have of late also installed economizers. They will be found in some of the newest large central stations. The load factor of the plant also has an important bearing on the installation of an economizer. In plants with high load factors for twenty-four hours, or even for a ten-hour day, an economizer might soon pay for itself, although it often would not be worth while to put one in a plant of the same size having a very low load factor.

Maintenance and operation charges are second in importance to fuel costs. These factors involve a consideration of the material and its life under the conditions of operation. Is the material suitable to withstand corrosion from the flue gases emitted by the coal used? Will it satisfactorily stand the pressures to which the economizer may be subjected? What are the repair charges that may be reasonably expected per year per unit? These are a few of the questions the engineer must decide for each particular economizer installation.

There are a number of other points that must be considered. For instance, the action of the scale-forming solids contained in the water should be investigated. It may be necessary to install a water-softening plant, and this added cost will have to be considered.

Then there is the cost of power to operate the scrapers that remove dust and soot from the tubes. To prevent sweating of tubes, with resultant corrosion and caking of soot, it is advisable to heat the water to not less than one hundred degrees Fahrenheit or, better still, two hundred and ten degrees before pumping it into the economizer. This requires a source of water at this temperature and may make a feed-water heater necessary. A device has recently been patented in England to recirculate the water in an economizer, prevent sweating and lessen both internal and external corrosion.

For best results the boiler and economizer should be supplied with heat from a smokeless furnace, as soot is one of the most difficult things to contend with in economizer operation. The underfeed stokers have been quite satisfactory in this respect.

It has been proposed to do away with the scrapers and equip the economizer with soot blowers only. At the present time no information is available regarding the success of plants so equipped. But if this scheme operates satisfactorily, the economizer installation cannot only be greatly cheapened, but the annoyance and trouble of operating scrapers will be done away with. However, the cost of the steam needed by the soot blowers must be charged.

The flue gas in passing through an economizer decreases in temperature, therefore it is generally necessary to provide mechanical draft to help out the chimney. This provides an added operating cost as well as increased first cost to be charged against the economizer. On the other hand, such draft equipment allows the boilers to be forced quickly in emergencies and also to meet peak loads, and in a measure partly offsets the added costs. The economizer must therefore be charged with all auxiliary power before its real saving can be determined.

In regard to available space such can usually be provided if the other considerations warrant the installation of economizers. Where land is valuable it is becoming standard practice to place the economizers directly above the boilers.

The first cost of the economizer is of course an important factor in arriving at a decision, but it should be considered only in connection with all the other factors. After investigating the problems involved in the consideration of economizers, one is led to ask if it is possible to build an economizer that would take less space, require less attention, have longer life and to some extent recover the heat lost by radiation from the boiler itself, as well as take heat from the flue gases.

Steam-Turbine Capacities

An editorial appeared in *Power* on November twenty-fifth, nineteen hundred and thirteen, on the limit of steam-turbine size about the time that an announcement was made that the Interborough Rapid Transit Company had purchased a thirty-thousand-kilowatt turbine. After reviewing the progress of steam-turbine development and commenting on a similar editorial discussion of the subject appearing in *Engineering*, of London, England, it was concluded that structural difficulties and high costs, together with questions as to advisability of such large units in stations, would limit the size of turbines to about thirty thousand kilowatts.

The year's review in *Power* of January fourth, nineteen hundred and sixteen, shows that several machines of thirty thousand and thirty-five thousand kilowatts are now in service, and forty-five thousand- and fifty thousand-kilowatt units are on order. This indicates that apparently both users and builders have decided to raise the limit of

size sixty per cent. above what was considered proper only a little over two years ago. It is further a source of considerable gratification to note that the initiative for such increases in size comes from American sources, as no large work has been undertaken in Europe since the war started. It may be also pointed out that if these great machines can be successfully built and if they produce the highly economical results expected from them, American manufacturers, on the basis of their experience with such successful machines, should be able to practically monopolize the South American and even the South African markets after the termination of the war. The opportunities in these directions should not be overlooked.

Such large turbines are desired because they utilize the heat available in the steam with higher degrees of economy than the smaller units. So far the efficiency of the steam turbine has improved with size, and apparently the end is not yet. It was feared a few years ago that the immense size of casings and rotors would make the turbines very costly to build, so that a limit in capacity would soon be reached on the basis of costs. While figures are not available on first cost per kilowatt, it is said that this is quite moderate. Furthermore, it was held that distortion troubles would make larger clearances necessary in the large turbines and hence lower economies would result. However, the introduction of Curtis-Rateau and Curtis-Parsons types, with double-flow low-pressure sections, and the division of the Parsons unit into two or more machines have not only generally allowed high speeds to be maintained but have permitted the efficiency of these units to be increased. At the same time manufacturers are learning more about blade forms and blade efficiency, and these are being steadily improved as the size increases.

With increasing size there is a tendency to increase boiler pressures and superheats, which in turn make more heat available for work per pound of steam during its expansion in the turbine, therefore smaller volumes of steam are present in the turbine per kilowatt output, or to put it in another way, the same low-pressure end will suffice for a turbine of greater output if the initial pressure and superheat are materially increased.

But higher initial steam temperatures on turbine blading sometimes produce undesirable results. Some materials in use with pressures of, say, one hundred and seventy-five pounds and superheat of one hundred degrees Fahrenheit become noticeably weaker at higher temperatures. Besides, the tendency is to increase blade speeds, and this combination of weakening of metal by heating, together with increased stress, will probably necessitate considerable development work in new blading materials. These new giants will call for much more expensive material in blades, shafts and casings.

An interesting phase of large steam-turbine development is the tendency to divide the expansion of the steam between two cylinders. In marine practice it has been divided among as many as four cylinders, corresponding in former engine practice to the four-cylinder triple-expansion engine. If it has been necessary to only use two cylinders on turbines of thirty-five thousand-kilowatt capacity, then on four-cylinder turbines arranged on this system it is likely possible to develop ninety thousand or more kilowatts, if the first costs are not too high, as already a seventy thousand-kilowatt, three-rotor turbine is being built for the Interborough Rapid Transit Company's Seventy-fourth Street power house.

It is interesting to consider the conditions that demand such large units. In general they are intended for service in plants of utilities serving a very heavy electrical demand. The large steam turbine, on account of its high economy, will be run continuously at as nearly full-load unity-load factor as possible, while fluctuations and peak loads will be taken generally by older and less efficient machines already installed.

It has been stated that greater subdivision of units would be more desirable, but the whole problem figures down to first and operating costs. A single large unit will undoubtedly generate more cheaply than two of half its size and will need less boiler capacity. Its first cost will also be less. The older units to meet peak loads are already installed and are not ready to be scrapped. So the logical unit is one of a size to carry that portion of the load of the plant that is practically constant for the twenty-four hours.

In one system where hydro-electric power is used it has been stated that the large steam turbines with the economical boilers can generate power cheaper than hydro-electric power, and it is now proposed to run the turbines constantly at full load and let the hydro plant supply fluctuations and carry the peak. It is held that this will result in the cheapest power.

Finally, one is led to ask what will the ultimate limit be to the size of steam turbines? Former predictions have failed. Apparently, the limit will lie only with what the utilities may demand. It is absurd to think that seventy thousand killowatts is the limit, and several years hence engineers may laugh at the idea that one hundred thousand-kilowatt units are not commercially possible. With the subdivision of the work in two or more cylinders, there is apparently now no limit in sight to the capacity of the steam turbine.

Everyone recognizes, and many have experienced, the difficulty in selecting a subject for a talk before an engineering society or a contribution to an engineering paper. Generalizing or attempting to cover the whole field or all of any considerable branch of it at one sitting usually fails, and worse, it fails to produce anything of lasting value. It is curious how often this is done even when the author has a special subject "down fine," on which he could give invaluable "pointers" in a concentrated form.

The American Society of Civil Engineers may move into the Engineering Societies Building.—News item. What a splendid addition it would make to the large family at Twenty-nine West Thirty-ninth St.

"Let the code decide" is the slogan of the National Association of Electrical Inspectors, meaning the Fire Underwriters' Code. Why not all interested in boilers use it too, now that there is one for boilers?

The Phantom Water Power Trust.—Headline. Perhaps; but with adequate government regulation the ghost would cease to be alarming.

If pumps and engines could talk, they would say terrible things about some engineers.

A manager usually learns that you can protect men against almost everything but themselves.

Correspondence

Operating Bleeder Turbines

I would like to hear from engineers who are using bleeder turbines—taking steam from the turbine casing for heating purposes. I do not doubt the economy of bleeding steam from a turbine for heating where the supply extracted is sufficient for the heating system, but I have grave doubts about its economy in plants where this steam must be supplemented by additional live steam from a high-pressure line.

In fact I believe it is a loss, particularly where the lay-out is such that the live steam through the reducing valve is introduced, as is often the case, into the heating main beyond the bleeder line, with no way of indicating the amount of steam taken from the turbine, as it is possible to simply maintain or tend to maintain a pressure in the turbine from the reducing valve, or at least get very little, if any, steam from the turbine. With a flow meter in the lines it would be easy to know what was happening.

If a pressure of five pounds is maintained at both points, the flow at the farther point must retard and choke off that from the first, and this would be the case as long as the pressure at the reducing valve is maintained equal to that in the turbine shell. Therefore it is difficult to be sure of the results merely by observation, as conditions may arise that will be misleading. I should like to hear from engineers who are blessed with the necessary equipment to enable them to know positively at all times what is doing. J. A. McGILLIWAY.

Trenton, N. S., Canada.

Cylinder Lubrication Question*

James Baudino asks in the issue of Feb. 8, page 192, how much cylinder oil it takes to properly lubricate an engine. It is my opinion that he uses too much oil, as 1 qt. per 8-hr. run is a lot. I operate one 15x24-in. engine at 110 r.p.m. with 120 lb. steam pressure and 6½ lb. back pressure, one 16x36-in. engine at 86 r.p.m. with the same initial and back pressure and an 8x8x8-in. air compressor at 50 r.p.m. and I have used 3 qt. of oil for the three in 10 days, running 10 hr. per day. I have been using oil at that rate for a month and the engines are running all right. I have been operating the 16x36-in. engine for 11 years and all the repairs to the cylinder consist of new piston rings in 1914. I allow the 16x36-in. engine one drop every six revolutions and the other one drop every 9 revolutions, or one drop for every 216 ft. of piston travel. They both have Corliss valves.

I use a heavy black oil, but do not know how much it costs per gallon. I do not know whether I can run continuously at that rate of feed or not, but the engines are running smoothly and there is no noise in the cylinder as yet. Both engines run belted generators in parallel. The reason for limiting the oil is that we use exhaust steam in the manufacture of tobacco. I would like to hear from others that do not use much oil.

Granby, Que., Canada. ALFRED F. BALDUS.

I think Mr. Baudino's oil consumption is fairly reasonable. Price is a poor guide for cylinder lubricating oil. I have tried out three different oils in this plant and find that I use less of the cheapest oil than of the others and get better lubrication.

A Russell single-valve engine requires considerable oil on account of the large valve surface and short travel, making it hard to get the oil under the valve. This does not, however, affect the over-all economy of the engine. When a Russell valve sticks for lack of oil or other cause, it pulls the governor toward the wide-open position, which causes racing.

If Mr. Baudino could induce his employers to install a cylinder-oil reclaiming outfit, he could cut his oil bill down to one-third and still use more oil in his engines, thereby saving both lubricant and engines at the same time.

I open up and examine my engines every four weeks to see whether I am using too much or too little oil and regulate the feeds accordingly. A. A. BLANCHARD.

Ringwood Manor, N. J.

The proper amount of oil to use in any given cylinder and the best grade to use can be determined only by trial, together with a knowledge of the characteristics of the plant. The quantity that Mr. Baudino reports as being formerly used seems reasonable, for cylinders large in proportion to the stroke, running at high speed and having a large valve-wearing area need more oil, especially if the steam is wet. A good way to determine whether enough oil is being used is to take the cylinder head and valve chest covers off and examine the wearing surfaces. If no bright spots or places where cutting is apparent are found or if there is enough oil on the cylinder and valves to show on a piece of white paper when rubbed over the surface, there is probably sufficient lubricant being used. If there is any doubt, it would be well to investigate the manner of distributing the oil to the wearing surfaces to see that the entire surface is getting its proportional amount.

Another governing point is the adaptability of the oil to the conditions rather than the price per gallon. As a rule the best cylinder oils for saturated steam are of a mineral base compounded with a varying percentage of animal or vegetable oils. Mineral oil does not have the property of adhering to a wet hot surface, while fatty oils do have that property, and it follows that when steam is moist a compounded oil will stick to the walls better than a pure mineral oil.

With a steam pressure of 90 to 110 lb., a different grade of oil would be required than for 150 lb. on account of the difference in temperature and moisture. If of the proper grade, the quantity allowed by the expert would

*Other discussion on this subject will be found in the issue of Feb. 22, page 266. Another series on a similar subject, "Cutting Down Cylinder Oil," appeared in "Power" Nov. 2, 1915, p. 602; Nov. 30, 1915, p. 673; Jan. 4, 1916, p. 23; and Jan. 11, 1916, p. 53.

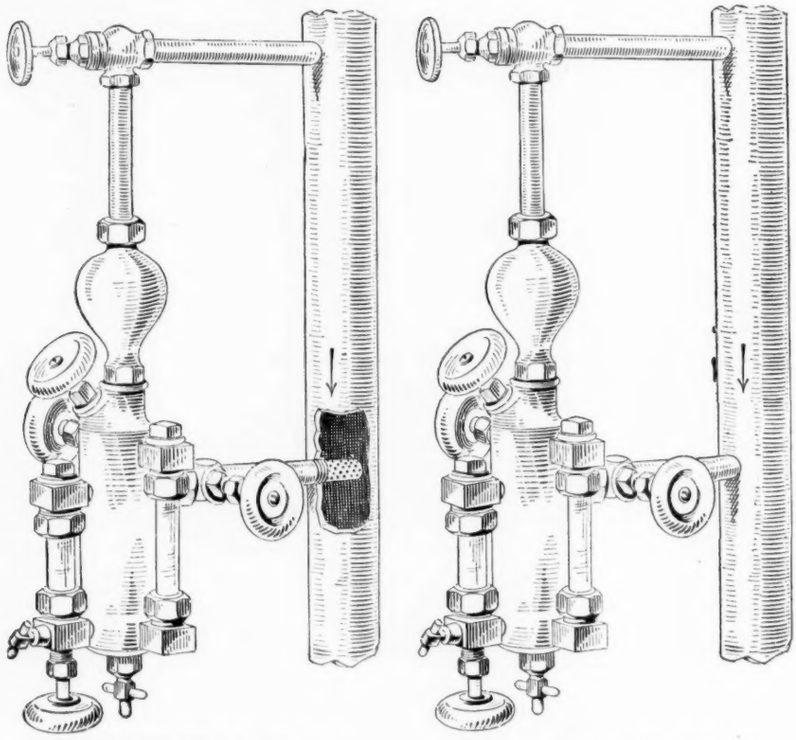
be sufficient. That, however, can be determined only by trial. If Mr. Baudino will refer to the issue of Jan. 4, page 23, he will find the amount of oil that we are using, which under our conditions is sufficient, as all the wearing surfaces show proper lubrication.

Evidently the oil expert reduced the consumption about 7 pt. per day of 12 hr., saving in 360 days (a year) approximately 315 gal., costing, say, $94.50. The increased steam consumption would be negligible, as only enough oil is required to prevent cutting and form a very thin film on the walls. There are many engines getting no more oil than Mr. Baudino's that have not been rebored in years, if at all, and are still in good operating condition.

He should not be satisfied until the valves and cylinder surfaces have been thoroughly examined—not once, but several times—and if found dry and actually in need of more oil, he should call the superintendent in and prove to him that more oil is needed. If, however, the inspections show that the cylinder is sufficiently lubricated, it may mean a clear saving of $95 per year—a matter that cannot be overlooked. J. C. HAWKINS.

Hyattsville, Md.

A double-ported 28x48 Corliss engine with double eccentrics, operating at 85 r.p.m., with a boiler pressure of 110 lb. gage, equipped with one triple sight-feed oiler and an atomized spray above the throttle, ran 72 hr. on 1 qt. of cylinder oil that cost $1 per gal. Another Corliss engine similar to the first ran so badly the engineer had to use a larger set of dashpots to close the valves, although using a good grade of oil and a large quantity; but this was a case of oil in the wrong place.



RIGHT: PERFORATED PIPE EXTENDING INSIDE

WRONG: PIPE END FLUSH WITH INSIDE

A Pacific type locomotive with cylinders 25x26 in. and a boiler pressure of 185 lb. superheated used 1 pt. of oil in each cylinder over a division of 175 mi. hauling 15 vestibuled coaches averaging 60 mi. an hr., but the oil was put in the right place at the proper time and was of a suitable grade. It may improve conditions to use a better oil or change the system of lubrication, or both. The illustration shows the right and wrong way to connect a cylinder lubricator.

Oil at 30c. per gal. might be good to oil a wheelbarrow, but a first-class engine should have good oil in the right place. W. B. SHIPPERSAR.

Memphis, Tenn.

[The discussion of cylinder lubrication seems to have aroused popular interest to an unusual extent from the liberal response. Statements of the amount of oil used in engines of a given size and type and, as one contributor expressed it in feet of piston travel per minute, afford the only basis for comparison.—Editor.]

Some Large-Unit Boilers

Referring to the article on large boilers in the Jan. 25 issue, it is well known that in 1904 double-ended Hornsby boilers, each having 21,700 sq.ft. of heating surface and 336 sq.ft. of grate surface, were installed in London; the furnaces were each 24 ft., or a total of 48 ft. furnace width.

The well-known Detroit Edison plants have still larger units—double-ended Stirling boilers each with 23,654 sq.ft. of heating surface, and two 26½-ft. furnaces, or a total of 53 ft. furnace width.

It appears clear from the illustration of a new German boiler near Düsseldorf, Fig. 2 of your article, that this is relatively quite a small boiler, composed of two units, each with drums about 9 ft. long; and except for the arrangement of the economizer, it seems to correspond with the diagrams of Fig. 3, which appear to show two 7-ft. units with 9-ft. drums, totaling about 470 sq.m., or say, 5,000 sq.ft. of heating surface per boiler, with two 6½x10-ft. chain-grates, say 130 sq.ft. of grate surface, and a 13-ft. furnace width of boiler.

The coal burned on such grates would correspond to the rating of 10,000 kg., or 22,000 lb. of steam hourly; so it would appear that the figures given apply to six such boilers—not to the one boiler illustrated, which obviously could not approach 132,000 lb. of steam per hour.

This new German boiler cannot possibly be efficient, as the superheater is placed at the rear of the boiler, and therefore to give superheated steam at 600 deg. F., the gases must leave the boiler at considerably higher temperatures than 600 deg.

The chief novelty of the German boiler shown appears to be the concentration of the maximum heat on the loops of the front tubes—precisely at the point where scale is most likely to form; and the article calls attention to the provision made for inserting a special cleaner in the front tubes.

Fig. 1 evidently shows in error the front drum reversed and indicates the downcomer tubes in the main path of the ascending gases; in Fig. 3 the actual arrangement of drum is shown, with the downcomer tubes adjacent to the front wall, where they are out of the main path of the gases and therefore of small value as evaporating surface.

In normal boiler plants the counter-current travel of water through economizer to boiler is standard practice, but the superheater is placed between the front and the rear banks of tubes, so that the gases can leave the boiler at a lower temperature than that of the superheated steam. This correct practice was followed in the huge boilers already referred to, installed in London in 1904, and is essential for good boiler efficiency.

Modern developments of mechanical stoking have eliminated all occasion for the coking arches and division walls as illustrated for the German boiler with its separate chain-grate furnaces. With multiple-unit underfeed stokers no arches or division walls are required whatever the width of boiler furnace; the whole space is available for active combustion. For example, the 16-retort continuous-cleaning underfeed stoker is suited for a 25½-ft. boiler with about 13,000 sq.ft. of heating surface and will carry any load up to, say, 5,000 kw. A double-ended boiler of the same width will naturally take two such 16-retort stokers and carry a 10,000-kw. load. Such flexible combustion, combined with continuous cleaning of fires and simplicity of setting, permits the use of large-unit boilers, while it insures proportionate results on smaller units.

ERITH'S ENGINEERING CO., LTD.,
London, England. Charles Erith, Director.

Siller-Christians Boiler

The article on the Siller-Christians boiler in the Jan. 25 issue is interesting, as it shows a type of water-tube boiler built with the idea of obtaining the maximum possible thermal efficiency.

As this boiler is a combination of economizer, boiler and superheater in one unit, it is not fair to compare its efficiency with that obtained from an ordinary water-tube boiler. However, the Commonwealth Edison Co. of Chicago installed in its Fisk Street Station a separate economizer for each boiler. An account of this was given in the Oct. 2, 1915, issue of *Power*. The efficiency of this unit installation should be comparable with the 90 per cent. efficiency of the Siller boiler.

Where an economizer is installed, it is usually necessary to provide induced draft. With the high efficiency obtained by the Siller boiler, the temperature of the flue gases certainly would be extremely low and undoubtedly induced draft would be required. The power for driving the induced draft fan, as well as that used by the stoker, is directly chargeable against the efficiency of the boiler, at least for comparison with other boilers.

As constructed, this boiler has no mud drum, and the bottom loop formed by the tubes of the "evaporator" is the logical place for scale and sediment to deposit. As this is directly over the fire, unless a clean feed water is used, there will likely be tube failures. With a condensing plant using a small amount of makeup water, this trouble would be reduced to a minimum.

Internal strains due to differences in temperature would be practically unknown in a boiler of this type, as all parts are kept at an almost uniform temperature because of the unique construction.

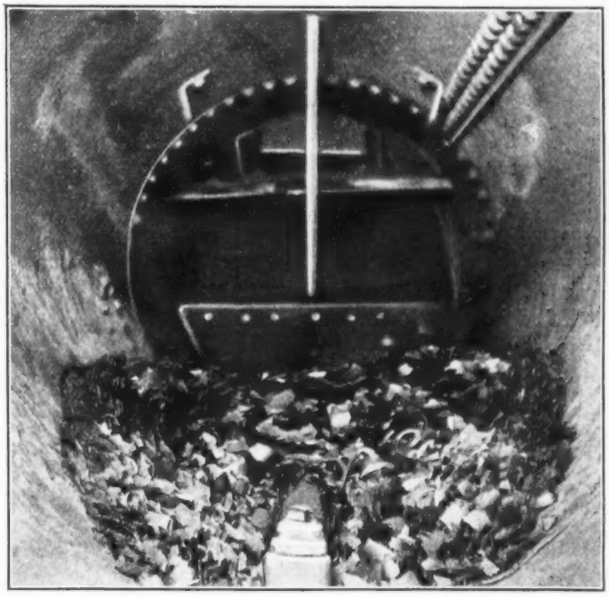
However, the thermal efficiency is not the deciding factor in an installation of this kind. The maintenance and depreciation must be looked after, that they do not overcome the increased thermal efficiency when computing the actual cost of the steam produced.

As the Siller-Christians boiler is of different construction from those built in this country, a more extended account of this apparatus, with figures covering cost of operation and maintenance would be appreciated. A comparison of the Siller boiler with a unit of the Fisk Street Station might show some interesting results.

Brooklyn, N. Y. WARREN D. LEWIS.

Circulation Carries Scale into Steam Drum

The photograph here reproduced was taken in one of the drums of a Heine boiler at the end of a three weeks' run after it had been equipped with a circulating device.[1]



SCALE DEPOSITED IN THE STEAM DRUM

As a rule, when opening this type of boiler for cleaning, most of the heavier scale is found in the bottom of the water legs or in the tubes, as the circulation is not rapid enough to carry it up into the drum.

From investigation and experiments carried out by the technologic branch of the United States Geological Survey and published in the Survey's Bulletin 23, page 278, it has been found that the average velocity of water through all the tubes is 60 ft. per min. The combined area of the tubes being about the same as that of the water leg, the circulation of the mixture of steam and water upward in the front leg cannot be much over twice this, or 2 ft. per sec., if we assume this mixture to be half steam and half water, which would be about correct for normal rating. This velocity is too low to carry much of the heavier scale up into the drum.

Chicago, Ill. R. CEDERBLOM.

[1]The Broman steam-separating and water-circulating device.

Loss Due to Combustible in Ash

The article on "Loss Due to Combustible in Ash" in the issue of Feb. 22, page 256, is wrong according to some technical literature on the subject.

Suppose, for example, you had a good grade of coal that contained only 1 per cent. ash. If an analysis of the refuse from the ashpit gave 50 per cent. combustible, the loss to the ashpit in percentage of total coal would be small. Another example: Suppose you had a very poor coal, about 50 per cent. ash, and that the refuse from the ashpit was as before, 50 per cent. combustible, you would have a loss of 100 per cent. of the original coal; that is, all of it went through the grate and none burned.

You will find on a heat balance sheet, such as used at the Ohio State University, or in Professor Somermeier's book on "Coal," the following: Let A = ash in coal; (1 — A) = combustible in coal; C = combustible in refuse; and R = incombustible, from which loss to ashpit $= \frac{CA}{R(1-A)}$.

It is evident that this loss will depend upon two independent variables and cannot be expressed by a single curve. The variation in the loss to the ashpit will be greater for any change in the analysis of the coal than for a change in the analysis of the refuse.

The loss to the ashpit is one that is often over-estimated, because it is so plainly visible, while the greater loss—that of heat up the chimney—is not so plainly manifest. Of course we should keep tab on all the losses, but undue attention paid to the ash pile almost invariably causes a larger loss by lowering efficiency somewhere else.

Columbus, Ohio. E. R. Andrix.

Icicles on the Stack

Fig. 1, a view of the roof of the power house at the University of Saskatchewan, Saskatoon, Canada, and Fig. 2, a nearer view of the top of the stack, are remarkable on account of the icicles and also of the good combustion indicated.

The diameter of the stack is 78 in. and the building is 84x120 ft. The stack extends 14 ft. above the roof. We have 28 rows long by 10 rows deep of Green economizers and in our power house there are two Babcock & Wilcox boilers of 319 hp. each, two Robb boilers of 250 hp. each and one Robb boiler of 125 hp. We have one Robb engine directly connected to a 30-kw. generator and one Bellas Morcom directly connected to a 125-kw. machine. We supply light and power to six buildings, besides a number of farm buildings, and in all, heat about 52,000 ft. of radiation. W. E. McLellan, an old subscriber of *Power,* is our chief engineer.

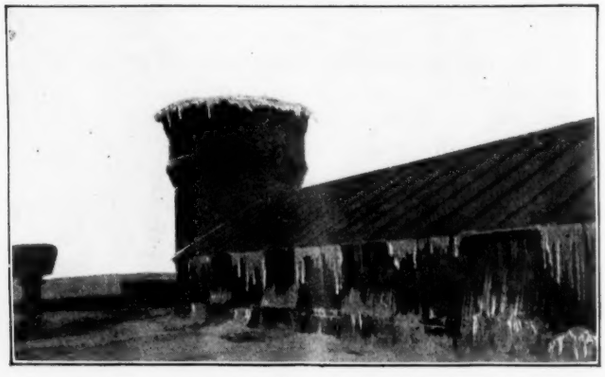


FIG. 1. NO VISIBLE SMOKE AND PLANT IS RUNNING

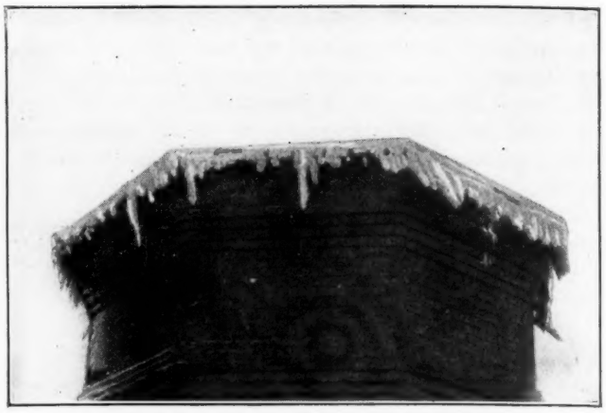


FIG. 2. NEARER VIEW OF STACK, SHOWING ICICLES

A. R. Greig,
Superintendent of University Buildings.
Saskatoon, Sask., Canada.

What Caused the Pressure Fluctuation?

In the Feb. 22 issue, Charles Haeusser asked what caused the pressure gage attached to a 150-hp. horizontal tubular boiler to fluctuate. He said that the boiler had been out of service for 18 hr. and the gage still showed 40 lb. pressure. The safety valve was raised for a moment, then a wood fire was kept going for half an hour, when unexpectedly the pressure suddenly fell to 30 lb., where it remained for 10 min., after which it rose normally until the usual pressure of 80 lb. was reached.

I believe that when the boiler was cut out of service the pipe connection to the gage was partly plugged and became completely plugged when the pressure was 40 lb. When the fire was started, circulation soon began, relieving the obstruction and causing the gage to register the true pressure of 30 lb. L. C. Kramer.

Berlin, N. H.

[If the gage-pipe connection were plugged, the water, which was getting colder and colder, would contract, showing a reduction in pressure and not maintaining a pressure higher than that in the boiler.—Editor.]

The Kelker Accident Not a Boiler Explosion

In the Feb. 22 issue I noticed an account of a boiler explosion at the plant of the Kelker Blower Co., in which it was stated that 15 lives were lost.

In the first place there was no boiler, as the source of power was a gas engine. As to the fatalities, a laborer and a girl stenographer were instantly killed and the wife of the owner died in the hospital several days after from the results of the disaster, which completely wrecked the plant. Four other employees were slightly injured. It was at first thought that the explosion was caused by acetylene gas, which was used for welding, but at a hearing to determine the origin, at which one of the experts from the acetylene company was present, it was ascertained

that the cause was an accumulation of natural gas in the basement.

In the gas line running to the engine was a connection with a pilot light on a gas-heated hot-water tank, and it was said that, when the engine was running, the pilot light would flicker or pulsate with each intake stroke of the engine, and it was concluded that the light was extinguished in one of these pulsations, and the gas, accumulating to a large volume, ignited from the engine ignition, with the resulting explosion.

Buffalo, N. Y. C. W. GEIGER.

The Pitot Tube Formula

Concerning the discussion of the pitot tube in the issue of Feb. 1, page 144, I desire to call attention to the fact that the correct formula is $V = \sqrt{2gh}$ instead of $V = \sqrt{gh}$, as given. It is evident that the Chief has studied an antiquated textbook. Henri Pitot correctly announced the formula as $V = \sqrt{2gh}$. In a discussion of a paper by the writer (in the Transactions of the A. S. M. E., Vol. XXII), William Kent announced that the correct formula was $V = \sqrt{gh}$. On Oct. 8, 1900, W. M. White, now hydraulic expert for the Allis-Chalmers Manufacturing Co., read a paper before the Louisiana Engineering Society, entitled "The Pitot Tube; Its Formula." From carefully conducted research work, he was able to prove that Pitot was right and Kent was wrong.

The trouble in interpreting results obtained in calibrating the pitot tube has been that the static openings of the tube do not always give the true static pressure. A suction will increase the reading of total head by depressing the static reading below the true amount. For instance, if a calibration shows the constant of the pitot tube to be 0.8, then $V = 0.8\sqrt{2gh}$ and $\frac{V^2}{2g \times 0.8^2} = h$; therefore $h = 1.56\frac{V^2}{2g}$.

If the Chief will read the paper by W. M. White, he will revise his ideas to agree with experimental facts. One may construct a pitot tube that will certainly give a coefficient of unity and may be sure that the correct formula is $V = \sqrt{2gh}$. W. B. GREGORY.

New Orleans, La.

[Upon again looking up the paper and discussion in Vol. 22, A. S. M. E., I find that Kent's closing statement was: "This theoretical formula, $H = c\frac{V^2}{g}$, applies to centrifugal pumps . . . in which the *velocity* is the *cause* and *head* is the *effect*, while $V = \sqrt{2gh}$ is the correct formula where *head* is the *cause* and *velocity* the *effect*." (The latter condition was really the basis of the talk.) In his closure in reply Professor Gregory seemed to contend chiefly against the use of a coefficient, preferring a tube calibrated so that none would be needed, for he said: "If we must always use a constant and express the formula $V = \phi\sqrt{gh}$, why not merely write $V = k\sqrt{h}$, where k is a constant?" In the present letter, after showing its application he again expresses in the closing paragraph his preference for a tube so calibrated as not to require a coefficient. There seems to be no difference between the two professors in the formula applicable to the head causing velocity problem, at least, being $V = \sqrt{2gh}$ straight when the coefficient is unity, so the correction should be made on page 146 accordingly.—Chief Teller.]

Interpolating Logarithms with the Slide Rule

It is sometimes necessary or desirable to interpolate logarithms closer than can be done by reading from the tables of proportional parts. This may be done easily with a slide rule and is the quickest and most satisfactory method I have found yet. Logarithms themselves are but a means of close approximation, but with such little kinks as this the approximation may be made very much closer. For example:

Let 7.0313053	=	log x.
From the table log 10,748	=	.0313277
Log 10,747	=	.0312872
Difference	=	405
.0313053	=	mantissa x.
.0312872	=	mantissa next smaller.
181	=	difference.

With the slide rule, over 405 on the D scale set the right index on the C scale and over 181 on the D scale read 4,465 on the C scale.

Annexing this value, 10,747,446.5 = x.

With proportional parts, 10,747,400 = x.

The decimal point here is not to be regarded, as the reading from the rule is simply annexed to the last figure from the table.

Let x = 1,051,465.7, to find log x:

From the table mantissa for 10,515	=	.0218093
Mantissa for 10,514	=	.0217680
Difference	=	413

With the rule, over 413 on D set the right index of C and under 657 on C read 272 on D.

Mantissa for 10,514	=	.0217680
Addition for 0000065.7	=	272
		.0217952

With the proper characteristic, log x = 6.0217952

Let x = 115,421.21, to find log x.

From the table, mantissa for 11,543	=	.0623187
Mantissa for 11,542	=	.0622811
Difference	=	376

Over 376 on D set the left index of C and under 121 on C read 45.5 on D.

Mantissa for 11,542	=	.0622811
Addition for 000001.21	=	46
		.0622857

With the proper characteristic, log x = 5.0622857.

The position of the decimal point in this case is found as follows:

If the slide projects to the left, there will be as many digits before the decimal point as there are in the difference between the mantissas taken from the table; if the slide projects to the right, there will be one less digit than above. Trigonometric functions can also be interpolated this way.

Let log tan ø = 9.6455479, to find ø.

Log tan 23°51′10″ =	9.6455729
Log tan 23°51′00″ =	9.6455160
Difference =	569
Mantissa for ø =	.6455479
Mantissa next less =	.6455160
Difference =	319

Over 569 on D set the right index of C and over 319 on D read 5.6 on C.

Therefore ø = 23 deg. 51 min. 05.6 sec.

This method can be used to advantage where no proportional parts are given.

With some practice one should be able to read from the tables and the rule without writing down any figures but the result. The time saving is considerable.

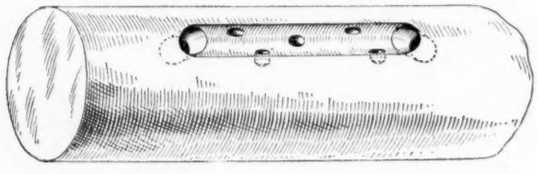
Springfield, Mass. H. B. SCHELL.

Emergency Repair to Piston Rod of Ammonia Machine

Recently I visited a plant having a 150-ton vertical ammonia compressor that I had operated years ago, and it brought back memories of several peculiar experiences and happenings in this plant. After chatting a while with the engineer, I climbed upon the machine to the first landing or platform, where I could command a good view of a particular ammonia piston rod. I found what I was looking for, began to laugh and remarked to the engineer: "Well, she is still there, and I guess for good." Naturally he was curious, and I related the story:

One night in the early spring when I was operating this machine, one of the stuffing-boxes on this compressor began to leak. I used a ¾-in. open-ended wrench to tighten the gland nuts and in some way managed to get the wrench caught between one of the nuts and the rod. Before I could jerk the wrench out, it plowed a furrow in the rod, ⅛ in. deep, ⅜ in. wide and 6 in. long.

I quickly stopped the machine and viewed what I thought was my "Waterloo" in this plant, as it probably



THE GROOVE READY FOR THE TIN

meant a new rod. "Why not fill the groove with something" was the sudden thought that struck me. I decided to use babbitt. The groove was too shallow to hold anything, so with a round-nosed chisel and a hammer I cut the groove to a depth of ⅜ in. the whole length of the score and drilled two ⅜-in. holes ¾ in. deep, one at each end of the groove, and in between these I drilled five ¼-in. holes ⅝ in. deep to hold the babbitt or material. The illustration shows how the rod was prepared.

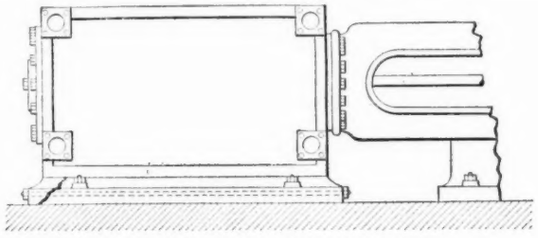
In the meanwhile the oiler was across the alley in the repair shop heating up a ladle of block tin, the only metal we could find, as the storeroom was locked. Lucky thing that we did not use babbitt, as later years proved that block tin was just the thing to use. After I finished drilling the rod, I made a mold out of wet cement—the only thing we could find. After the tin had cooled, I removed the mold, peened the tin into the rod and filed off the excess metal to a smooth finish.

On inquiring about the oiler that helped me on this night and his whereabouts, I was informed that he was assistant master mechanic of this same plant.

Chicago, Ill. C. E. ANDERSON.

Repaired Cracked Engine Frame

The cylinder base on the low-pressure side of a cross-compound Corliss engine developed a crack on the head end, as shown in the sketch. Considerable speculation



THROUGH BOLTS FOR CRACKED ENGINE BASE

was indulged in as to the best means of making a repair, and it was decided to do the job with bolts.

Accordingly, two 1⅜-in. through-bolts, each 4 ft. 9½ in. long, were obtained and two holes drilled through each end of the engine base so as to line up with each other. The bolts were put in place and brought under tension by screwing up on the two end nuts.

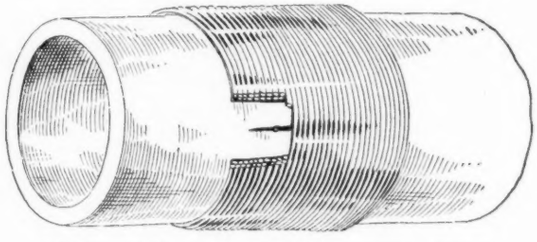
So far as can be determined the repair makes the base rigid, and the crack has not increased in length since putting the bolts in place. GEORGE ROLLINS.

Providence, R. I.

Stopping Leaks in Pipes

An effective way in which to stop leaks in pipes, particularly those caused by cracks, consists in wrapping wire in a double layer around the pipe over the leak. Furnace cement or Smooth-on is about the most suitable substance to put on the pipe to fill up the interstices and will serve to make the layers and pipe one solid mass.

The wire will strengthen the pipe at the same time and prevent its bursting. The wire should be applied as hot



LEAK CLOSELY OVERLAID WITH WIRE

as possible, so that it will not expand after being wrapped on. If it is put on heated, it will bind tightly on the pipe when it contracts while cooling and will usually be found effective. A. P. CONNOR.

Washington, D. C.

Inquiries of General Interest

Direct-Acting Steam Pump—What is meant by a direct-acting steam pump? J. H.

A direct-acting steam pump is one having the water and steam ends centrally in line with each other, with the water and steam pistons attached to the same piston rod without the intervention of a crank or other mechanism for transmission of power from the steam piston to the water piston of the pump.

Use of Reverse-Current Relay—What is the purpose of a reverse-current relay? J. F. C.

A reverse-current relay is one that acts to open the circuit upon a reversal of the energy flow. It is often employed as a protection against current reversal where the line is fed by storage batteries and converters; also on the generator leads in some direct-current installations to prevent motorizing of one of the units should its voltage fall considerably below that of the other machinery.

Effect of Angularity on Compression—How does the angularity of the connecting-rod of an engine affect compression of the exhaust? F. L.

On account of the angularity of the connecting-rod, less than one-quarter of the revolution of the shaft is accomplished during the time the piston is traversing the head-end half of a stroke, and as the movement of the valve depends on the angular displacement of the eccentric along with the shaft, the valve travel is less during the head-end half of the stroke. As the compression of the exhaust results from closing the exhaust before the end of the stroke, then when the piston is traveling toward the crank end of the cylinder, the valve will move quicker. Hence, with the same inside lap the exhaust would be closed earlier and the compression would be greater in the crank end than in the head end of the cylinder.

Trouble from Fire-Door Arch—We are having trouble with burning out of the fire-door arch in the setting of a flush-ended return-tubular boiler. How can this be remedied? G. G.

Burning and failure of the fire-door arch undoubtedly result from the flow of highly heated furnace gases through cavities in the front wall of the boiler setting direct to the smoke uptake. This is a condition likely to arise after short use of a front wall that has not been built up solidly, with the brickwork thoroughly bonded and grouted, or where disintegration is induced by an imperfect sealing off of the heated gases where the front wall laps over the under side of the boiler. The best provision against crumbling of the wall is to provide single-span firebrick arch blocks; or where these are not obtainable, the front wall should be taken down and rebuilt from the foundation, of sufficient thickness to lap not less than 6 in. against the under side of the boiler. The changes may require a broader dead-plate and shortening up of the furnace, or moving the furnace and bridge-wall farther to the rear, but they will insure a more durable fire-door arch and less waste of furnace heat.

Clicking Noise in End of Cylinder—A 12x30-in. Corliss engine has given considerable annoyance at times on account of a knock, or click, in the head end of the cylinder. There is no jar, and sometimes the engine will run smoothly for a whole week. The engine makes good indicator diagrams, and the average load is about 80 hp. What might be the cause and remedy? J. A. W.

If the piston rings are intact, a clicking noise such as described would most likely be due to striking of the piston rings against the sides of the grooves in the piston, induced by sudden change of pressure on one side of the piston or unusual friction of a ring in passing over the cylinder walls, due to a different lubrication or temporary disturbance of the cylinder alignment from unequal expansion.

Careful examination of the bore of the cylinder should reveal whether it needs reboring for correction of alignment or unevenness that may cause the ring to drag harder under some conditions of cylinder-wall lubrication than others. If the cause is not to be attributed to the condition of the cylinder, the clicking probably arises from the use of a different quality of steam or a change in the rate of lubrication that results in the presence of less condensate or oil between the rings and sides of the grooves to resist the lateral movement of the rings from sudden change of cylinder pressure or dragging on the cylinder. The remedy for such movement would be to provide rings that fit more snugly in the sides of the grooves of the piston.

Electromotive Force Generated by Gramme Armature—What would be the total electromotive force produced by a dynamo having a Gramme-wound armature with 300 wires all around the armature, the number of c.g.s. lines per square centimeter of the armature core being 16,000, the cross-sectional area of the core 125 cm., and the speed 30 r.p.s.? J. W. D.

The electromotive force may be expressed by the following formula:

$$E = \frac{\phi \times W \times \text{r.p.m.}}{3{,}000{,}000{,}000 \times b}$$

where

E = Electromotive force;
ϕ = Number of lines passing from pole to pole through the armature;
W = Number of wires all around the armature;
b = Number of paths through the armature winding.

In the absence of anything to the contrary, consider a two-pole machine with a simple two-circuit winding; then

$$\phi = 2 \times 125 \times 16{,}000 = 4{,}000{,}000$$
$$W = 300$$
$$b = 2$$
$$\text{r.p.m.} = 30 \times 60 = 1{,}800$$

Substituting,

$$E = \frac{4{,}000{,}000 \times 300 \times 1{,}800}{3{,}000{,}000{,}000 \times 2} = 360 \text{ volts.}$$

Reduced Pressure for Steam Heating—What effect will it have on steam economy and the heating capacity of coils for heating a mill to 70 deg. F., at present supplied with live steam at 75 lb. boiler pressure, if the supply is furnished through a pressure-reducing valve that reduces the pressure to 10 lb. gage? S. M. H.

At a boiler pressure of 75 lb. gage, or 90 lb. absolute, the temperature of the steam is 320.3 deg. F., and each pound of dry saturated steam at that pressure contains 1,184.4 B.t.u. above 32 deg. F. Neglecting the small loss by radiation, each pound of dry saturated steam discharged through the reducing valve would contain the same number of heat units, and if discharged at 10 lb. pressure the temperature of the steam would be 290.1 deg. F.; that is, it would be superheated 50 deg. F. above 240.1 deg. F., which is the temperature of dry saturated steam at the pressure of 10 lb. gage. On account of the lower temperature and superheated condition of the steam at the reduced pressure, there would be less loss of heat by radiation from the supply lines and branches and also less loss of heat by wastes such as from discharges of bucket traps to the atmosphere.

Under ordinary conditions the steam in the coils from being brought in contact with condensate, would immediately be reduced to the temperature of dry saturated steam at 10 lb. gage pressure, or 240.1 deg. F., and the effectiveness of the coils per square foot of heating surface for warming the air to 80 deg. F. would thereby become $\frac{240.1 - 70}{320.3 - 70}$, or about two-thirds as great as when the coils are supplied with steam at 75 lb. boiler pressure. Aside from the reduction of line losses and wastes incident to the use of a reduced pressure, the same amount of steam will be required from the boiler for a given amount of heating as when using steam at boiler pressure, and the principal advantage in the use of a pressure-reducing valve would result from the convenience and economy of reducing the supply to actual requirements and relieving the pipe system of unnecessary pressure.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Fuels for Steam Boilers*

By William Kent

SYNOPSIS—The properties of various solid, liquid and gaseous fuels, and their relative adaptabilities to different conditions considered from both a technical and an economic standpoint.

Probably 90 per cent. of all the fuel used for steam boilers is coal. The choice of fuel for a boiler plant depends upon its availability, the market price, the net amount of heat that may be obtained from it and utilized in the generation of steam, and upon its bulk as related to its heat value. Following is a list of the various fuels:

Coal: anthracite, semibituminous, bituminous, lignite, coal briquettes, pulverized coal, coke.

Peat, wood, sawdust, spent tanbark, bagasse, straw, cotton-seed hulls, corn.

Petroleum: fuel gas, petroleum distillates, residuum, gas-works tar, alcohol.

Natural gas, producer gas, blast-furnace gas, coke-oven gas.

The utilization of these fuels will be considered in inverse order.

GASEOUS FUELS UNDER STEAM BOILERS

Natural gas is the ideal fuel wherever it can be obtained in sufficient quantities and at a price low enough to compete with coal. About 1885 the supply of gas in western Pennsylvania was so abundant that it was generally adopted as a fuel for steam boilers in Pittsburgh, but in a few years, as the supply of the gas wells decreased and the use of gas for domestic purposes, metallurgical furnaces and gas engines increased, the price was raised so that it was no longer an economical fuel for steam boilers.

As an approximate rule for the relative economy of natural gas and good bituminous coal as a fuel for steam boilers, it may be said that if natural gas can be delivered in the boiler room at 10c. for 1,000 cu.ft. (measured at atmospheric pressure and 60 deg. F.), it will pay to use it if the price of good bituminous coal delivered in the boiler room is $3 or more per 2,000 lb.; or if coal costs $6 per ton, it will pay to use gas at 20c. per 1,000 cu.ft.

Producer gas has often been suggested as a steam-boiler fuel and frequently tried, but it has never been adopted on a large scale. The producer as heretofore built cannot be driven so as to consume as much fuel per square foot of ground space occupied as can an ordinary boiler furnace. This limitation has been a fatal objection to its general adoption.

The waste gas from blast furnaces has generally been used as fuel both for heating the blast and for the boilers supplying steam to the blowing engines. The quantity of gas made is usually sufficient for both purposes and in many cases is more than sufficient, so that a great deal goes to waste. In recent years there has been a tendency to save this surplus gas by using it in gas engines furnishing electric current for rolling mills or other purposes, and in the building of new furnaces it is becoming common to use gas-engine instead of steam-engine blowing apparatus.

THE USE OF LIQUID FUELS

Petroleum and its various products make excellent fuels for steam boilers, and they will be used instead of coal whenever they can be obtained in quantity and at a price sufficiently low to show a commercial advantage in using them. The lighter distillates—gasoline, benzine and kerosene—are in general too high-priced to be used, since there is a large demand for their use in oil engines and for other purposes. The heavier distillates, such as lubricating oils and paraffin, are for the same reason unavailable as fuels. There remain as commercial fuels the crude petroleum as it comes from the well, fuel oil and the residuum left after distillation of kerosene and the lubricating oils. The world's total annual consumption of petroleum and its products as fuel is probably not over 2 to 3 per cent. of the coal consumption, and the relatively limited and variable supply always tends to make the price more or less unsteady.

Fuel oil is now extensively used as a fuel for warships to economize space and weight and on account of its convenience in handling. It is also used in locomotives and in steam-power plants in the Southwest because of its cheapness compared to coal in that section.

Representative figures for the composition, weight and fuel values of different American oils are given in Table 1 (from "Power").

TABLE 1. PROPERTIES OF CRUDE OIL

Kind of Oil	—Composition by Weight— Carbon	Hydrogen	Sulphur	Oxygen	Specific Gravity	Pounds per U.S. Gal.	B.t.u. per Lb. by Test
Ohio	0.834	0.147	0.006	0.013	0.800	6.68	19,580
Pennsylvania, light	0.820	0.148	0.010	0.022	0.816	6.80	19,930
Pennsylvania, heavy	0.849	0.137	.....	0.014	0.886	7.40	19,210
West Virginia, light	0.843	0.141	0.003	0.013	0.841	7.02	18,400
West Virginia, heavy	0.836	0.133	0.008	0.024	0.873	7.28	18,324
Texas	0.840	0.132	0.010	0.018	0.925	7.71	19,100
California	0.852	0.124	0.005	0.019	0.959	8.00	18,500
Average	0.839	0.139	0.007	0.018	0.871	7.27	19,006

Table 2 is from an article by R. W. Fenn, in "Engineering News," May 13, 1909, showing the range of values of California oils.

TABLE 2. PROPERTIES OF CALIFORNIA OILS

Deg., Baume	Specific Gravity	Weight per Bbl.	B.t.u. per Lb.	Thousands B.t.u. per Bbl.
10	1.000	350	18,380	6,442
15	0.966	339	18,680	6,323
20	0.934	327	18,980	6,212
25	0.905	317	19,280	6,113
30	0.875	307	19,580	6,008
35	0.849	298	19,880	5,917
40	0.825	289	20,150	5,827
45	0.802	281	20,400	5,732

From these figures it appears that the thinner and lighter the crude oil the higher is its heat value per pound, but the less per barrel. Table 3 shows the relative values of petroleum and coal, based on the following assumed data: B.t.u. per lb. of oil, 19,000; specific gravity, 0.90 = 7.5 lb. per U. S. gal.; 1 bbl. = 42 gal. = 315 lb.; 1 ton coal = 2,000 lb.

TABLE 3. RELATIVE VALUES OF OIL AND COAL

Coal B.t.u. per Lb.	1 Lb. of Coal = Lb. of Oil	1 Bbl. Oil = Lb. Coal	1 ton Coal = Bbl. Oil
10,000	1.900	598	3.34
11,000	1.727	544	3.68
12,000	1.583	499	4.01
13,000	1.462	460	4.34
14,000	1.357	427	4.68
15,000	1.267	399	5.01

Large purchasers of fuel oil in California buy on specifications, of which the following, issued by the Southern Pacific Railway system, is an example:

It must contain no sand or foreign matter in the shape of sticks, waste, stones, etc., and must be sufficiently liquid to flow in 4-in. pipes at a temperature of 70 deg. F. Oil containing more than 2 per cent. of water and other impurities will not be accepted. Fuel oil will not be accepted for general use the flash point of which is less than 110 deg. F. when tested in the open cup (Tagliabue method), the oil to be heated at the rate of 5 deg. per min. and test flame applied every 5 deg., beginning at 90 deg. The specific gravity should range between 0.98 and 0.88 (13 deg. and 29 deg. Bé.) at 60 deg. F.

Coal tar, a gasworks byproduct, is sometimes sold at a price low enough to allow of its being used as a boiler fuel. Two analyses given by C. F. Pritchard are as follows:

	Carbon	Hydrogen	Nitrogen	Oxygen	Sulphur	Ash	Specific Gravity	B.t.u. per Lb.
Coal-gas tar	89.21	4.95	1.05	4.23	0.56	trace	1.25	15,708
Water-gas tar	92.70	6.13	0.11	0.69	0.37	trace	1.15	17,193

PEAT, WOOD, REFUSE AND THE LIKE

The composition of these fuels differs from that of coal in two chief particulars: They contain when air-dried usually as much as 25 per cent. moisture, by weight, and when wet, 50 per cent. or more; and when completely dried, the fuel, free from moisture and ash, contains from 32 to 48 per cent. of oxygen and only from 45 to 60 per cent. of carbon. The hydrogen in the dry fuel is in the neighborhood of 6 per cent., but it is largely, if not entirely, neutralized by the oxygen. The ash found in different samples is variable, ranging from 1 to 15 per cent.

Taking average compositions of these several fuels, computing the heat value of the dry fuel by Dulong's formula with an addition of 10 per cent., assuming that the moisture in the wet fuel is 25 per cent. and 40 per cent., that this moisture together with that formed by the combustion of the fuel is evaporated and superheated to 512 deg. F., the assumed temperature of the chimney gases, we obtain the figures in Table 4 as the available heat value. In making the calculations the ash is neglected and the hydrogen is taken in all cases at 6 per cent. The available heat value of these fuels

*From a paper on the "Economy of Steam Plants Using Gas, Gasoline, Coal and Other Pan-American Fuels," read before the recent Pan-American Scientific Congress.

ranges from one-quarter to a little over one-half of that of the highest grades of steam coal, the available heat value of which, when low, in ash and moisture, is about 15,000 B.t.u. per lb.

In the utilization of these fuels in steam boilers, it is necessary to burn them in specially designed furnaces with roofs of firebrick and extremely large combustion chambers.

TABLE 4. HEAT VALUE AND COMPOSITION OF PEAT, WOOD, TANBARK AND STRAW

	Fuel Dry and Free From Ash					Total B.t.u. per Lb. Available —Moisture—	
	C	H	O	N	Dry	25%	40%
Peat	58.8	6.0	34.8	0.4	10,569	7,850	5,428
Wood	51.3	6.2	41.9	0.5	8,962	5,895	4,464
Tanbark	52.6	6.1	41.3	...	9,088	5,990	4,440
Straw	47.7	6.0	46.7	0.6	7,769	5,001	3,748

Their great bulk for a given heat value and the high percentage of moisture they contain make them impracticable as commercial fuels unless they can be obtained at very low cost, as byproducts, except in a few localities where, on account of lack of transportation facilities, coal or oil is not obtainable at reasonable prices. The cost of digging peat and drying it to make it suitable for fuel has hitherto prevented its use for steam boilers in the United States, although it has been used to a limited extent in Europe.

Corn has been used as a fuel in Nebraska in years when the selling price was very low and that of coal high. Its heat value is about the same as that of wood. Boiler tests have shown the relative values of corn and Nebraska coal to be as 1 to 1.9, and that corn at 10c. a bushel would be as cheap as coal at $5.11 per ton.

Bagasse, the refuse cane from sugar mills, is successfully used as fuel in Louisiana, Cuba and other sugar-producing countries, furnishing enough steam to run the mills. The conditions for its proper utilization are that it can be made as dry as possible by the cane rolls and preferably further dried by the waste heat from the boiler furnaces, and that it can be burned in suitable furnaces.

COALS AND THEIR CLASSIFICATION

The quality of coal depends chiefly upon the location of the coal mine. The best steam coal in the United States, known as semibituminous, is found in vast quantities in a narrow strip of territory about 10 to 20 mi. wide in the Appalachian coal field running from central Pennsylvania to northern Alabama. At the northeastern end of the field in a limited district in eastern Pennsylvania are the anthracite mines, and west and northwest of the semibituminous strip, reaching to central Ohio and central Kentucky, Tennessee and Alabama, is the great area of Appalachian field, in which a high-grade bituminous coal is mined. Of the two great central fields, one, covering nearly the whole of the state of Illinois and parts of western Indiana and western Kentucky, known as the Illinois basin, produces generally a medium grade of bituminous coal, and the other, known as the Missouri basin, covering parts of Iowa, Missouri, Nebraska and Kansas, produces chiefly a low grade of coal, although some of the coal mined in Kansas is of high grade.

In a narrow strip of territory in Arkansas and Oklahoma and also in a few places in Colorado some semibituminous coal is found. In Colorado and in Washington all grades from anthracite to lignite are found, but the coal-bearing areas are small. Throughout the remainder of the United States west of the Missouri River there are numerous small areas containing coal, but most of it is of poor quality, classed as lignite or sub-bituminous. In Alaska all grades of coal from anthracite to lignite are found, and there are some large deposits of semibituminous awaiting development.

The quality of coal may be judged from its chemical composition. The moisture it contains is of two kinds—the surface, or accidental, moisture of wet coal, which may be dried out by exposing the coal in a thin layer to the ordinary atmosphere of a room for from 24 to 48 hr.; and inherent, or hygroscopic, moisture, which the air-dried coal contains and which cannot be removed from a lump of coal except by heating it for some time to a temperature of about 240 deg. F. or drying it for some weeks in a dessicator with sulphuric acid or calcium chloride. The amount of this inherent moisture is the first criterion for judging the character of a sample. If it is less than 2 per cent., the coal is either anthracite, semianthracite, semibituminous or high-grade bituminous. If it is above 4 per cent., it is medium or low-grade bituminous or lignite. The volatile matter found in the proximate analyses, calculated as volatile matter in the combustible, or coal dry and free from ash, is the next distinguishing characteristic of different coals. If it is less than 10 per cent., the coal is classed as anthracite; 10 to 15 per cent., semianthracite; 15 to 30 per cent., semibituminous; above 30 per cent., it may be either bituminous or lignite.

The author's classification of coals is given in Table 5, ("Transactions American Society of Mechanical Engineers" 1914; "Steam Boiler Economy," second edition, 1915, p. 73). It divides the bituminous coal into three grades—high, medium and low—the chief distinction between them being the percentage of moisture found in the coal after it is air-dried. The coals highest in inherent moisture are also highest in oxygen.

TABLE 5. CLASSIFICATION OF COALS

Class	Volatile Matter, Per Cent. of Combustible	Oxygen in Combustile, Per Cent.	Moisture in Air-Dry, Ash-Free Coal, Per Cent.	B.t.u. per Lb. of Combustible	B.t.u. per Lb. Air-Dry Ash-Free Coal
I. Anthracite	Less than 10	1 to 4	Less than 1.8	14,800 to 15,400	14,600 to 15,400
II. Semianthracite	10 to 15	1 to 5	Less than 1.8	15,400 to 15,500	15,200 to 15,500
III. Semibituminous	15 to 30	1 to 6	Less than 1.8	15,400 to 16,050	15,300 to 16,000
IV. Cannel	45 to 60	5 to 8	Less than 1.8	15,700 to 16,200	15,500 to 16,050
V. Bituminous, high-grade	30 to 45	5 to 14	1 to 4	14,800 to 15,600	14,350 to 14,400
VI. Bituminous, medium-grade	32 to 50	6 to 14	2.5 to 6.5	13,800 to 15,100	11,300 to 14,400
VII. Bituminous, low-grade	32 to 50	7 to 14	5 to 12	12,400 to 14,600	11,300 to 13,400
VIII. Sub-bituminous and lignite	27 to 60	10 to 33	7 to 26	9,600 to 13,250	7,400 to 11,650

FURNACES FOR STEAM BOILERS

The first requirement for a steam-boiler furnace is that it shall have sufficient coal-burning capacity, and this means not only a grate surface large enough to burn the coal at such a reasonable rate of driving (measured in pounds of coal per square foot of grate surface per hour) as will not cause the clogging of the fire with clinker, but also a combustion chamber so large that the gases distilled from the coal may be completely burned in it before they come in contact with the heating surfaces of the boiler, thus preventing the formation of smoke and soot when soft coal is used, and the escape of unburned gases when anthracite is the fuel. In modern practice the size of the combustion chamber, relative to the size of the boiler, has been greatly increased as compared with the practice of ten years earlier. It is now not uncommon to have the tubes of a water-tube boiler of the B. & W. type, with the tubes inclined 15 deg. from the horizontal, placed 12 ft. or more above the grate bar, and in the case of the recent forms of Stirling boilers, with steeply inclined tubes, to have the furnace extend more than 20 ft. above the grate bars. The conditions for the complete combustion of coal without smoke are as follows:

1. The gases of combustion are distilled from the coal at a uniform rate.

2. The gases when distilled are brought into intimate contact with very hot air.

3. That the gases shall enter a firebrick chamber of either sufficient volume to allow the flaming gases to be entirely consumed naturally or that the chamber be provided with such auxiliary baffling or mixing devices as will cause them to be mixed before the exit of the chamber is reached.

With the furnace conditions as stated and with ample air supply, coal may be burned without smoke, but in order that economy as well as smokelessness be obtained, it is necessary that the air supply be restricted to such an extent that the excess of air above that theoretically necessary to effect complete combustion be not greater than 25 per cent. To effect this restriction the chimney gas must be analyzed or its percentage of carbon dioxide or oxygen continuously indicated by some form of indicating apparatus.

OXYGEN IN GASES VS. EFFICIENCY

In plotting the efficiency obtained in numerous boiler tests and comparing them with the results of analyses of the chimney gases, it is found that maximum efficiencies are obtained only when the carbon dioxide is between 14 and 15.5 per cent., but when it is in excess of 15 per cent. the efficiency may be either at or near the maximum or considerably below it, since a high percentage of CO_2 may be accompanied with high CO, indicating a loss due to imperfect combustion. The percentage of free oxygen in the gases is a more satisfactory criterion of the furnace conditions leading to high efficiency. If it is below 3 per cent., the CO nearly always is found to be too high for maximum efficiency, and if it is above 6 per cent., there is too great a loss of heat in the chimney gases, owing to the heating of an unnecessary excess of air to the temperature of the gases.

In the author's "Steam Boiler Economy," second edition, page 316, there is given a rather complex formula, based upon theoretical considerations, and several sets of curves showing the relation of boiler efficiency to the several variable conditions that enter into boiler performance. The application of this formula to certain assumed cases gives the results shown in the tables given later. Table 6 shows the composition of the dry chimney gas derived from burning Pittsburgh bituminous coal with different quantities of air. Case (1) is an

TABLE 6. COMPOSITION OF DRY CHIMNEY GAS

Case	Per Cent. of C Burned to CO	Per Cent. Excess Air	Dry Gas per Lb., Fuel = f.	Dry Gas per Lb. Carbon	Analysis of Dry Gas by Volume CO_2	CO	O	N
(1)	0	0	11.60	13.98	18.45	0	0	81.55
(2)	0	20	13.83	16.66	15.30	0	3.56	81.14
(3)	0	50	17.16	20.67	12.18	0	7.09	80.73
(4)	0	100	22.72	27.37	9.10	0	10.57	80.33
A	5	0	11.36	13.69	17.85	0.94	0	81.21
B	5	20	13.23	15.93	15.18	0.80	3.12	80.90
C	10	0	11.12	13.40	17.21	1.92	0	80.87
D	20	0	10.65	12.83	15.88	3.97	0	80.15

ideal but not a practical case, since it is not possible in practice to burn all the C to CO_2 without excess of air. Cases (2), (3), (4), A and B are all within the range of ordinary practice (which sometimes shows 200 per cent. or more excess air), and cases C and D represent either the conditions of too heavy firing and choked air supply, or the condition existing a minute or two after firing of fine moist slack coal, which temporarily chokes the air supply and causes the formation of a great volume of smoky gas. Cases (2) and A represent the best possible practice, reached only when all conditions are most favorable.

Table 7 shows the maximum theoretical efficiencies that may be reached with the same coal with the stated air supply and with different rates of driving. ($\frac{W}{S}$ = pounds of water evaporated from and at 212 deg. F. per hr. per sq.ft. of heating surface.)

TABLE 7. THEORETICAL EFFICIENCIES WITH PITTSBURGH COAL UNDER DIFFERENT CONDITIONS

Case	(1)	(2)	(3)	(4)	A	B	C	D
Per cent. C to CO	0	0	0	0	5	5	10	20
Per cent. excess air	0	20	50	100	0	20	0	0
$\frac{W}{S}$ =	Efficiencies, per cent.							
0.5	74.76	73.68	72.05	68.97	72.53	71.61	69.77	65.79
1	81.13	79.78	77.73	73.72	78.69	77.54	76.23	71.34
2	84.06	82.30	79.60	73.90	81.53	80.02	78.98	73.87
3	84.49	82.34	79.02	71.72	81.91	80.09	79.35	74.16
4	84.24	81.71	77.79	68.91	81.64	79.50	79.09	73.85
6	83.03	79.76	74.65	62.60	80.43	77.65	77.91	72.64
8	81.47	77.45	71.17	55.87	78.87	75.48	76.39	71.11
10	79.77	75.01	67.55	49.20	77.17	73.15	74.74	69.45
12	77.99	72.48	63.86	42.37	75.41	70.76	73.02	67.72
14	76.16	69.92	60.12	35.48	73.58	68.32	71.27	65.97

Tables 8 and 9 show the theoretical efficiencies obtainable from five different kinds of coal and an average fuel oil, the analyses of which are given, on the assumption of complete combustion with 20 per cent. excess air supply and rates of driving $\frac{W}{S}$ from 1 to 14 lb.

TABLE 8. ANALYSES OF FIVE COALS AND CALIFORNIA FUEL OIL

	Anthracite Dry and Free from Ash	Semi-bituminous	Pittsburgh, Ash and Sulphur Free	Illinois	Lignite	California Fuel Oil
Per cent. moisture	.....	1.7	2.0	10.8	27	0.2
Carbon	94.3	85	83	61	47	84.9
Hydrogen	2.3	4.5	5.5	4.2	3.3	11.9
Oxygen	2.4	3.2	8.0	9.6	12.0	1.9
Nitrogen	1.0	N.S. and Ash—4.6	1.0	1.2	1.0	.....
Sulphur	.....	.....	.....	(Ash and S) 13.2	.....	1.1
B.t.u. per lb.	15,000	14,950	14,908	10,640	8,250	19,600

TABLE 9. RELATION OF EFFICIENCY TO QUALITY OF COAL

Rate of Driving, W	1	2	3	4	6	8	10	12	14
	Efficiencies, per cent.								
Anthracite	81.85	84.56	84.71	84.16	82.39	80.25	77.95	75.59	73.19
Semibitum.	80.41	82.96	83.00	82.38	80.42	78.10	75.64	73.12	70.54
Pittsburgh Bitum.	79.78	82.30	82.34	81.71	79.76	77.45	75.01	72.48	69.92
Illinois	78.28	80.59	80.44	79.64	77.34	74.71	71.93	69.09	66.20
Lignite	75.83	77.76	77.51	76.52	73.98	70.90	67.79	64.62	61.40
Fuel Oil	78.78	81.61	82.01	81.71	80.52	78.97	77.26	75.48	73.58

When the figures for efficiency given in Table 9 are plotted, the resulting curves show a maximum at or near a rate of driving of 3 lb. of water evaporated per hour per square foot of heating surface, the evaporation falling rapidly to zero as the rate of driving is less than 1½ lb., but at higher rates than 3 lb. the curves approach nearly to straight lines, so that for these higher rates simple straight-line formulas may be used to show the relation of the efficiency to the rate of driving. The straight-line formulas corresponding to the figures for the several kinds of fuel (with an error less than 1 per cent.) are as follows:

Anthracite ..... $E = 84.7 - 1.05 (W \div S - 3)$
Semibituminous ..... $E = 83.0 - 1.13 (W \div S - 3)$
Pittsburgh bituminous ..... $E = 82.3 - 1.13 (W \div S - 3)$
Illinois bituminous ..... $E = 80.4 - 1.29 (W \div S - 3)$
Lignite ..... $E = 77.5 - 1.46 (W \div S - 3)$
Fuel oil ..... $E = 82.0 - 0.77 (W \div S - 3)$

In all cases the efficiencies given are the maximum obtainable under the conditions stated. They assume perfect combustion (except in the four cases A, B, C and D, in which the gases contain CO), no loss due to unburned hydrocarbon gases, to leaks of air into the boiler setting or to moisture in the air, a moderate loss of radiation (about 2½ per cent. of the heating value of the fuel when the boiler is driven at a rate of 3 lb. per sq.ft. of heating surface per hour, and one-half of this when driven at a 6-lb. rate), a clean boiler and the gas passages so baffled as to prevent short-circuiting of the gases.

In the best modern practice, under the most favorable conditions, the highest efficiencies given in the tables have almost been reached. A few tests with fuel oils have shown figures slightly higher. The best record yet obtained with coal is that of the best 10 out of 16 tests at the Delray station of the Detroit Edison Co., reported by D. S. Jacobus in the Transactions American Society of Mechanical Engineers," 1911.

All the tests thus far studied have failed to indicate that boiler efficiency has relation to the type or form of boiler, to the diameter of the tubes or to the velocity of the gases. All types and proportions of boilers have given efficiencies that are very close to the maximum when the furnace and boiler conditions were favorable, and the air supply properly regulated.

The most important conclusion to be drawn from the figures in the tables is that when the air supply is excessive, it is impossible to drive a boiler at a rate exceeding 3 lb. evaporated per square foot of heating surface per hour without a very rapid falling off in efficiency, but that when the air supply is regulated in accordance with the indications of the analyses of the gases, so as to keep the oxygen in the gas within the limits of 3 and 6 per cent. or the excess air in the neighborhood of 20 per cent. of that theoretically required for complete combustion, it is possible to drive a boiler to the extreme rate of 14 lb. per sq.ft. of heating surface per hour with a falling off in efficiency or less than 1.5 per cent. for each 1 lb. increase in the rate of driving.

An Association Formed for Water-Power Development

Offices were opened in Washington, D. C., Feb. 28, by a new national association which will launch a campaign of publicity designed to aid the administration in securing the passage of laws to encourage the development of water powers in the public domain and the navigable streams. The new organization, which calls itself the Water Power Development Association, is composed of manufacturers of waterwheels, hydraulic and electrical machinery, equipment and supplies, whose business has been seriously injured by the stagnation in hydro-electric construction work in the last few years, and who look forward to a revival of the industry and an increased business when the general dam act and the leasing bill for the power sites in the public domain, supported by the President and by Cabinet officers, are enacted into law.

In a statement issued by Marcus A. Beeman, secretary of the association, concerning its aims and purposes, it is asserted that the country has been greatly misinformed regarding the facts about the water-power industry and the legislative situation, and the new organization proposes to carry on a campaign of publicity that will present the facts. Mr. Beeman says:

The purpose of the Water Power Development Association is to tell the truth about water powers and the water-power business. We intend to tell the American people the facts that have been kept from them as to why our water powers are allowed to flow to waste while we burn coal at high prices to generate power. We propose to expose the crime that has been committed in locking these natural resources from use and keeping them locked from use, and the benefits that will accrue to the whole nation from development and use, as well as to make plain what kind of legislation is necessary to induce investment in water-power development.

There seems to be a unanimity of opinion that legislation of some kind is needed. The President of the United States, Secretary of the Interior Franklin K. Lane, former Secretary of War Lindley M. Garrison, the Public Lands Committees

and the Committees on Commerce of both the Senate and House, have all recommended legislation. The House of Representatives has passed bills to permit use of power sites in both the public domain and the navigable streams. There are some differences of opinion as to the details of this proposed legislation, but we believe that all the persons named are disinterested and sincere in their recommendations and that these differences of opinion are not vital.

Our association is not committed to any particular bill or any particular plan or program of legislation. It desires only such legislation as will bring development and use of the water powers, and which will fully protect both the interests of the public and of investors in these enterprises.

The affairs of the association are in the hands of a committee made up of Harry W. Hand, vice-president of the I. P. Morris Co., Philadelphia, waterwheel builders; W. W. Nichols, of the Allis-Chalmers Manufacturing Co., Milwaukee, makers of waterwheels and electrical apparatus; Chester W. Larner, of the Wellman-Seaver-Morgan Co., Cleveland, waterwheel manufacturers; J. E. Way, of R. Thomas & Sons Co., East Liverpool, Ohio, insulator manufacturers; and Calvert W. Townley, of the Westinghouse Electric and Manufacturing Co., Pittsburgh, manufacturers of electrical apparatus and supplies. Marcus A. Beeman, secretary of the association, has been assistant secretary of the Cleveland and Buffalo Chambers of Commerce, and Secretary of the New Jersey State Chamber of Commerce.

Mr. Beeman said recently that an announcement would be made later of the complete membership list of the association.

Congress Takes Up the Myers Water-Power Bill

Having disposed of the Shields water-power development bill, now in the hands of the House of Representatives, the Senate proceeded on Mar. 14 to a consideration of the Myers amendment to the Ferris bill—"An act to provide for the development of water power and the use of public lands in relation thereto, and for other purposes."

The Ferris bill, which passed the House on Jan. 8, has been entirely changed and rewritten by the Senate Committee on Public Lands and, as presented by Senator Myers, offers little in common with the bill to which it is supposed to be an amendment.

The provision of the original clause of the Ferris bill relating to the preservation of national forests or other public reservations has been entirely stricken out of the bill and in its place a clause introduced providing that "no lease shall be granted unless the applicant has complied with the laws of the state where the project is to be located."

The Ferris bill provided "that the lessee shall at no time contract for the delivery to any one consumer of electrical energy in excess of 50 per cent. of the total output, except upon the written consent of the Secretary of the Interior." This clause has been entirely stricken from the Myers bill.

The Secretry of the Interior was empowered under the Ferris measure to supervise the issuance of stocks and bonds by the lessee. Under the Myers bill this power is conferred upon no one in particular, but the Interstate Commerce Commission is given jurisdiction over the regulation and control of service and charges for service to consumers, in the event that the generation or transmission of power crosses a state boundary.

The provision of the original bill providing that, except upon the written consent of the Secretary of the Interior, no sale or delivery of power shall be made to a distributing company except in an emergency, and then only for thirty days, has been cut out of the Myers bill, which merely provides that any successor to the original lessee shall be subject to all the conditions of the first lease.

The price to be paid by the Government, in taking over the water-power property after three years' notice, was defined by the Ferris Bill as including "the actual costs of rights of way, water rights, lands and interests therein purchased and used by the lessee in the generation and distribution of electrical energy and, second, the reasonable value of all other property taken over, including structures and fixtures acquired or erected, such reasonable value to be determined by mutual agreement between the Secretary of the Interior and the lessee." In the Myers bill this purchase price is defined as "fair value of the property, to be determined by mutual agreement between the Secretary of the Interior and the lessee."

The term of twenty years, fixed by the Ferris bill for the execution of contracts beyond the actual life of the original lease, is extended by the Myers bill to twenty-five years.

Section 9 of the Ferris bill, providing for the direct jurisdiction by the Secretary of the Interior over all matters pertaining to the issuance of bonds, stocks, the regulation of rates and service, in the event that the state in which the leased property lies has no public utility commission empowered to attend to these matters, has been cut out of the Myers bill entirely.

The bill now under consideration in the Senate also includes four new sections covering matters not dealt with in the Ferris measure:

Section 16—That where only 10 per cent. or less of the lands actually necessary and required for the construction, maintenance and operation of dams and other works are lands of the United States Government and such Government lands are to be used only for overflowage, reservoir or transmission purposes and not in whole or in part as a dam site or the site of a power house, the Secretary of the Interior may, in his discretion, lease such lands to an applicant for not more than fifty years, at such rental price and upon such terms as he may consider just, free from all the terms and requirements of this act which the Secretary of the Interior may see fit to waive.

Sections 17 and 18 confer authority upon the States of Colorado and New Mexico to institute actions at law against the Secretary of the Interior to determine the rights of their citizens to appropriate and apply to beneficial uses the waters of the Rio Grande River and its tributaries within these states.

The final section of the Myers bill provides that the lands leased under this act may be used and the works constructed thereon added to or enlarged by the lessee or any other person, association or corporation, for the purpose of impounding water for the generation and distribution of power for irrigation, mining, municipal, domestic and other beneficial purposes, whenever such use of water is authorized by the state wherein said project is situated and under the authorization of the Secretary of the Interior.

OPPOSITION FROM COLORADO SENATORS

During the two days of Senator Myers' presentation of his bill to the Senate he was constantly interrupted by Senators Shafroth and Thomas, of Colorado, who, it was seen at this time, would lead the opposition to the Myers bill on the ground that it attacked state rights, was entirely too broad in its provisions and threatened the loss of the public lands. Senator Shafroth, after introducing a bill which he desired to have considered as a substitute to the Myers bill, launched into a bitter attack on the Myers measure on Mar. 17, in the course of which he said:

In the consideration of this bill I wish to call the attention of the Senate to the fact that this is the first of a series of bills that will follow. The program of the advocates of these measures is to adopt a leasing bill for water power on the public domain. The next proposition is to provide for the leasing of the coal, oil, gas, phosphate, potassium and sodium lands of the United States. These bills are to be followed by still another one, because that is the program of the so-called conservationists. They adopted in their conventions the program that all the mineral lands are to be subject to a leasing system by the Federal Government.

Now, whether or not this leasing system will be carried out, I cannot say, but unquestionably, when we consider this proposition of leasing the waters on the public domain by the Federal Government—waters that the Government has no more right or title to than you have—I think that we are getting to a state where we ought to consider this question most seriously. I am entirely satisfied myself, I am thoroughly convinced, that the passage of this bill will be a disaster to the Rocky Mountain States and to the country as a whole."

The Senator from Colorado then proceeded to quote from a number of decisions of the Supreme and other courts showing that the Federal Government has and can have no jurisdiction over the non-navigable streams and that its authority over the navigable streams is only of a negative nature—that is, to prevent obstructions to navigation. The original thirteen states owned their own water, Senator Shafroth pointed out, and every state admitted since that time has come into the Union "on an equal footing with the original states in all respect whatever." The Senator continued:

Therefore if the Congress of the United States were to pass a direct act providing for a charge for the use of water in any state, the Supreme Court of the United States would declare it unconstitutional. In addition, this bill invades the sovereign right of the State of Colorado, as well as every other state, to control its non-navigable waters. This is due to the fact that this bill denies the right of eminent domain. Whenever any company or any person is legally constituted to bring a condemnation suit under the laws of the state, they have a right to have the land sought at a valuation that would be placed upon it in a condemnation suit, and whenever the Federal Government attempts to vary that right it abridges the power of eminent domain of the state. If it can say, "We will require the payment of 25c. a horsepower," it can say "We will require $1,000 a horsepower." It differs only in degree. If it has the power in the one instance, it has the power in the other. It is a fact that it seizes the power of eminent domain and says, "You cannot exercise the right of eminent domain which you have set forth in your statutes and in your constitution." For that reason the pending bill is an invasion of the sovereignty of every state, in addition to being entirely unconstitutional.

Chicago Section A. S. M. E. Discusses Oil Engines

On Friday evening, Mar. 17, the Chicago section of the American Society of Mechanical Engineers held its largest meeting of the season in the Hotel La Salle; over 200 were in attendance to listen to S. B. Daugherty, of the Snow Steam Pump Works, talk on oil engines. Unfortunately the author was unable to be present, and the paper was read by his assistant, H. C. Lehm.

In reviewing the present oil production, the various fields from which it is obtained and the characteristics of the oil in each field, the author stated that the annual oil production had increased from 2,000 bbl. of 42 gal. each in 1859, which was the beginning of the production of petroleum, or mineral oil, to 265,762,535 bbl. in 1914. A general survey of the statistics showed that the total production of oil in the United States is increasing, the increase being in the lower-grade oils obtained in the southwestern part of the country. New fields are being discovered and the limits of old fields are being extended, so it is probable that for many years the total production will increase.

VERTICAL VS. HORIZONTAL ENGINES

In a comparison of vertical and horizontal Diesel engines the detail that is most discussed is the piston. Vertical builders call attention to the weight of the piston and the side pressure thereby produced on the cylinder bore in case the engine is horizontal. The fact that the first Diesel engines were built vertical and excessive height was undesirable probably led to the use of trunk pistons. For the same reason a connecting-rod of a length but slightly more than five cranks had been used with vertical engines. An analysis of the forces prevailing throughout the cycle of operations shows that the side pressure on cylinder walls due to the angularity of the connecting-rod is far greater than the pressure due to the weight of the piston, even though the piston lies horizontally. Any increase in connecting-rod length means a proportional decrease in the side thrust. Ordinarily an increase in the length of the connecting-rod of one crank length decreases the side thrust an amount equal to the weight of the piston and wristpin; in other words, a vertical trunk-piston engine with a connecting-rod five cranks long is subject to about the same side pressure on the cylinder wall as a horizontal trunk-piston engine with a connecting-rod six cranks long. A diagram was presented and an analytical analysis made to prove the foregoing assertion. It was concluded that it made very little difference whether an engine was built vertical or horizontal in so far as side pressures were concerned.

An advantage of the horizontal engine in general and the crosshead type in particular is, in the author's opinion, its superior accessibility. In the case of a vertical trunk-piston engine it is necessary to practically dismantle the engine to get at the piston rings or wristpin bearings. In most cases the valve gear and cylinder head must be removed, the connecting-rod must be disconnected at the crankpin, and the piston and rod then lifted out through the cylinder.

In the horizontal engine the sheet-steel crank splasher is removed; then the connecting-rod is disconnected at the crankpin in the case of a trunk-piston type or more simply at the wristpin if the engine has a crosshead, and the piston is removed from the open end of the cylinder. The actual time required to remove a piston and crosshead from a 19x33-in. engine was 20 min. The piston was wiped clean and replaced in 30 min., making the total shutdown 50 min., as compared with about one day of ten hours to accomplish the same thing in the case of a vertical engine.

The matter of cylinder lubrication is another feature of superiority in horizontal engines. In the vertical type it is essential, in order to secure a distribution of the lubricant around the cylinder bore, to supply the oil through a number of feeds—as many as four per cylinder on the smallest sizes and more on larger diameters. A horizontal cylinder on the other hand, even of the largest size that it is practical to build, can be effectively lubricated over its whole surface from a single feed on the upper side. Gravity helps distribute the oil.

In any internal-combustion engine some of the lubricating oil is carbonized. In a vertical engine this carbon tends to work down past the piston, fouling the rings and dropping into the crank pit, where it becomes mixed with the bearing oil. In the horizontal type much of this carbon is pushed into the counterbore, from whence it can be removed through a blowoff valve in the bottom of the cylinder.

Even the main bearings in a horizontal engine are more effectually lubricated. During the working stroke, when the pressures are highest, the main shaft is partly lifted from the bottom shell, allowing the lubricant to fill the space. Then on the two idle strokes, the exhaust and inlet, inertia effects tend to bring the shaft first against one side of he bearing, then against the other, thus promoting a thorough distribution of the oil.

For comparison the effective thermal efficiencies of various prime movers are about as follows:

Noncondensing steam engines, per cent.	8.4 to 6.6
Condensing steam engines and turbines using superheated steam, per cent.	15 to 10
Suction-gas engines, per cent.	23 to 18
Four-cycle Diesel engines, per cent.	34 to 32

A slide was presented showing the fuel-consumption curve of a single-cylinder four-stroke-cycle engine. From 80 per cent. to full load the consumption was practically constant, and at the rate of 0.42 lb. per b.hp.-hr. At this rate one gallon of oil will furnish about 18 b.hp. and the cost for fuel per brake horsepower-hour with oil at 3c. a gallon is 1.66 mills.

The opponents of internal-combustion engines, both gas and oil, always state that these engines are economical only when operating near their rated capacity, and that the economy falls off rapidly as the loads decrease. On the curve presented the load was approximately 42 per cent. where the consumption curve crossed the 0.5-lb. line, and the consumption at half-load was 0.47 lb. The fuel consumption for a ten-hour day running at half-load would be about 32½ gal., costing at 3c. per gal., about 95c. At quarter-load the cost of fuel for a day would be about 58c. By actual test on a 65-hp. engine, full speed without load was maintained on 1.1 gal. per hr.

WHY DIESEL ENGINES ARE NOT IN MORE GENERAL USE

With this showing of economy it may be asked why Diesel engines are not in more general use in the United States, where so much oil is produced. One answer, advanced by the author, is that those who are in a position to reap the most benefit are ignorant of the possibilities. Perhaps they have heard of an oil-engine installation that has not come up to expectations. Without investigation, they immedaitely condemn oil engines in general. Or it may be that even when an engine of a suitable type has been installed, satisfactory operation is not obtained on account of the failure of the men in charge to properly care for the engine.

It is evident that in a machine that requires uniformly high pressure to properly ignite the fuel charge, any appreciable leakage of valves or piston rings results in faulty ignition. This applies to the compressor that furnishes the spraying air as well as to the power cylinder. On the other hand, a little intelligent care will prevent trouble of this kind.

Another cause of trouble that is avoidable is overloading. A moment's consideration will make plain the ill effects of overloading. In any internal-combustion engine the amount of fuel burned is limited by the oxygen in the charge of air at the end of the compression stroke. In the case of a Diesel engine the time available for burning the fuel charge at full load will not exceed 35 deg. of crank travel. In the case of an engine running at 200 r.p.m., this is equivalent to $^1/_{34}$ of a second. During this time the oil must enter the cylinder, come in contact with the necessary oxygen and be consumed. There must of necessity be some excess oxygen to effect complete combustion of the fuel. The effect of overloading is to increase the fuel charge so that the amount is greater than can be burned clean with the air that is available. The result is that combustion continues after expansion has begun, and if the overload is great, it may even be that the charge is still burning when the exhaust valve is opened. The temperature of the exhaust gases are then so far above normal that the valve becomes distorted with the heat, causing leaks which still further aggravate the trouble. If an engine is allowed to run with a leaking valve, it is only a question of a few hours until both valve and seat are cut out by hot gases blowing through at high velocities.

The secret of success in operating a Diesel engine is taking care of these relatively small items. The owner who condemns a Diesel engine is generally careless, allows the engine to get out of order in some small particular, and then complains about unreliability, high cost of repairs, etc.

FIELD OF THE DIESEL ENGINE

The Diesel engine has a fairly well-defined field in which it will have no competitor when its merits are known and appreciated. This is the relatively small plant which, when steam operated, is usually inefficient. In generating electric current for a small town savings are effected that would justify the installation of the engines if the cost were two or three times what it actually is.

In ice making the cost of fuel per ton of ice with oil at 3c. per gal. is around 18 to 20c. per ton of ice produced. This includes driving all auxiliaries, lighting the plant, etc.

For pumping, the combination of an oil engine with a geared power pump makes a unit that has a higher efficiency from a thermal standpoint than the best crank-and-flywheel pumping engines, and this efficiency can be obtained with an oil engine as small as 65 hp.

Where heat units in coal can be purchased enough cheaper than heat units in oil, this advantage of the higher efficiency of the oil engine is offset, but it is probable that there is no place in the United States where the power requirements for pumping are around 50 to 60 hp. that an oil-engine driven pump would not be the more economical, all things considered.

The ability to generate electric power cheaply by means of Diesel engines has led to the installation of engines of this type in the phosphate-mining industry in Florida. The plants are operated continuously except for Sunday shutdown. It has been found that multistage centrifugal pumps, motor driven, will deliver water at the high pressure required for hydraulic mining at an expense that compares favorably with compound condensing pumping engines. The advantage of this combination lies in the ability to shift the pump and motor with but little trouble as the mining progresses, thereby saving the expense and losses due to extending pipe lines from a permanently located pumping unit.

The pipe-line companies have come to appreciate the merits of the oil engine for driving pumps. A large number of units have been installed, mostly of relatively small sizes. Now that horizontal Diesel-type engines are to be had, larger units are being used. The economies effected are such that it is only a question of time when steam engines for this service will be abandoned.

Replying to the discussion following the presentation, Mr. Lehm stated that the foregoing comparisons between vertical and horizontal engines applied to engines of less than 500 hp. Above this rating and for marine use the vertical engine had its field. Among those discussing the paper it was the consensus of opinion that the development of the Diesel would be in the larger powers rather than in the smaller.

It has been the common impression that Diesel engines use a large quantity of lubricating oil. In the early designs this was true, the speaker admitted, but engines of the present day will take about 0.4 gal. per 1,000 hp.-hr., or about one-third of the former consumption.

OBITUARY

DR. CHARLES J. H. WOODBURY

Dr. Charles Jeptha Hill Woodbury, a noted authority upon fire hazards, ecenomics, engineering and textile affairs, died at his home in Lynn, Mass., Mar. 20, aged 64. He was born at Lynn, was educated at the Massachusetts Institute of Technology, and for 13 years was assistant engineer of the American Bell Telephone Co., with headquarters at Boston. For the past 22 years he had been secretary of the National Association of Cotton Manufacturers, and he had a continental acquaintance with engineers in many different fields.

DANIEL HALLADAY

Daniel Halladay, builder of the heat engine invented by John Ericsson, the designer of the famous ironclad "Monitor," died recently at Santa Ana, Calif., where he had lived for the past 36 years. Mr. Halladay was born in Marlboro, Vt., 89 years ago, and at the time Ericsson's engine was developed, he was foreman of the American Machine Works, of Springfield, Mass. He was in charge of the exhibit of the engine at the London Exposition of 1851. He was a prominent citizen of Santa Ana and had extensive local banking connections.

ENGINEERING AFFAIRS

Rhode Island Association No. 2, N. A. S. E., of Pawtucket, held an entertainment at its meeting rooms Saturday, Mar. 11. There was a large attendance of members and friends, including the ladies. A program of musical and literary numbers was enjoyed, and refreshments were served.

The New Jersey State Association of the National Association of Stationary Engineers will hold its annual convention in the Auditorium, Paterson, N. J. The Lansdowne Hotel will be headquarters. Thomas McNamara, chief engineer for the National Silk Dying Co., East Fifth St., is chairman of the convention committee. Exhibitors will have from May 22 to June 12 to move in and out.

The American Institute of Steam Boiler Inspectors of New York City will hold its next meeting at the Engineering Societies Building, 29 West 39th St., on Friday evening, Mar. 31, at 8 o'clock. Joseph McNeil, the former head of the Boiler Inspection Service of Massachusetts and the present chief inspector of the Hartford Steam Boiler Inspection and Insurance Co., will be the speaker of the evening.

The New York School of Heating and Ventilating held its fourth annual dinner Monday, Mar. 13, at Stewarts' Restaurant, Park Place, New York City. This year the attendance was unusually large, there being 140 present. M. J. Sage was the toastmaster and introduced the following speakers, who made brief and interesting addresses: Frank K. Chew, W. H. Driscoll, Wilton W. Franklin, H. A. Pratt, J. J. Blackmore, Homer Adams, James A. Donnelly and C. W. Obert. Jack Armour, of "Power," entertained at intervals during the evening. The conductor of the school is Charles A. Fuller, M. E., and G. G. Schmidt, of 132 Nassau St., is the secretary.

John Scott Legacy Medal—The City of Philadelphia, acting on the recommendation of the Franklin Institute, has awarded the John Scott Legacy Medal and Premium to Clement F. Street, of New York City, for the Street locomotive stoker. The increase in the size of locomotives during recent years has resulted in such large requirements in amount of fuel burned that, in order to obtain a corresponding power output from the engine, quantities of coal considerably beyond the capacity of ordinary firemen must be handled. The Street mechanical locomotive stoker has been designed for keeping the fire in direct relation to all conditions of operation of the engine, and for securing the maximum output of large engines. Over six hundred of these stokers are in use and are understood to be giving satisfaction.

The Brotherhood of Power Workers will hold an open meeting in Harmony Hall, Worthington St., Springfield, Mass., Apr. 3, at 8 p.m. Mr. Stewart, of the Stewart Boiler Works, Worcester, Mass., will give an instructive lecture on boilers and boilermaking. There will be on hand for inspection boiler plates, rivets, handhole and manhole plates, the different kinds of stays and braces, lap and butt joints. The Brotherhood of Power Workers was organized Sept. 9, 1910, at Springfield, Mass., and is incorporated under the laws of Massachusetts. It is composed of engineers, firemen, oilers, helpers and all others engaged in the generation or transmission of power. Its objects are: To promote a system of education that will raise the efficiency of its members to secure the results accruing from a higher efficiency, to assist members to obtain employment and to pay sick, accident and death benefits. The brotherhood has proved popular in the western part of Massachusetts and already has six thriving locals.

Classified Ads

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ANSWERS addressed to us at 10th Ave. and 36th St., New York or 1144 Monadnock Block, Chicago will be forwarded without charge (excepting circulars or similar literature).

IMPORTANT: Original letters of recommendation or other papers of value should not be enclosed to unknown correspondents—send copies. Advertisers' names will not be furnished under any circumstances. Copy received until 10 A.M. Tuesday for following Tuesday's issue. P

POSITIONS OPEN

Illinois

LARGE CENTRAL-STATION COMPANY in Middle West offering excellent opportunities along engineering and commercial lines is seeking applicants in its drafting room on electrical construction of switchboards and general layout of central and sub-station design in connection with installations of large turbo-generators, synchronous converters and transformers; prefer applicants who have completed four years' electrical or engineering course, but men who have had one or two years of college training supplemented by additional study and experience since leaving school may qualify; salary ranges from $70 to $90 per month, depending entirely upon the qualifications of applicants; men who have had training with this company in the drafting department are later transferred to positions in the testing department, and those who wish to seek commercial work are given an opportunity to enter into new business fields; in replying, please give complete information as to age, qualifications and experience and minimum salary considered. Address replies to P752—Power, Chicago.

Pennsylvania

DETAIL DRAFTSMEN wanted; one experienced in air-compressor work; also one experienced in oil and gas engines. Address P739—Power, giving references; state age and salary wanted.

GAS ENGINEER, to operate a producer-gas power plant; a man familiar with double-acting horizontal engines preferred; state age, experience, salary expected; location eastern Pennsylvania. P744—Power.

SEVERAL FIRST-CLASS DRAFTSMEN wanted at once, of general mill and blast furnace experience; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P687—Power.

SEVERAL DRAFTSMEN wanted at once, experienced in power plant and general piping work; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P688—Power.

Employment Agencies

CORRESPONDENT

THE UNDERSIGNED plans and conducts correspondence for positions in technical, manufacturing and professional lines; $2500 to $15,000 men exclusively; complete privacy assured; no commission charged—only service fee and postage. Send name and address only, in confidence, for prefatory details. R. W. Bixby (established 1910), P1 Niagara Square, Buffalo, N. Y.

POSITIONS WANTED

Connecticut

CHIEF ENGINEER open for position; 20 years' experience in large plants; highest efficiency assured; strictly temperate; best of reference. PW746—Power.

Georgia

YOUNG TECHNICAL GRADUATE in electrical engineering desires position as assistant to superintendent of large steam plant; capable of taking charge of office routine and conducting tests with view of decreasing operating costs; now employed but desire change; age 24; single; strictly temperate; good references; moderate salary. PW751—Power.

New York

POWER-PLANT OPERATING ENGINEER or assistant; licensed man; experienced in the care and operation of engines, boilers and auxiliary equipment; immediately available; location immaterial. PW678—Power.

ERECTING AND MAINTENANCE ENGINEER, 19 years' practical experience, desires position in charge of installing and upkeep of electrical and general industrial plant equipment; 44 years old; married. PW747—Power.

WANTED

MANUFACTURER wants either patented or patentable ideas on boiler and engine room specialties; cash or royalty basis. W676—Power.

AGENTS AND SALESMEN

ENGINEER AND PATENTEE of numerous successful high-grade valves and steam specialties desires connection with manufacturer. W748—Power.

REPRESENTATIVES for a new type of a thoroughly established and successful steam specialty. State experience and territory covered. W629—Power, Chicago.

HIGH-GRADE STEAM SPECIALTY SALESMAN, five years' experience with present firm, seeks connection with reliable firm; Philadelphia territory preferred. W750—Power.

AGENTS handling engine and boiler room specialties, in every section, for side line, paying large commissions. Give experience, lines carried and territory covered. W390—Power.

A LIVE POWER-PLANT SPECIALTY SALESMAN who can qualify will have an opportunity to join the sales force of a well known manufacturer on a commission proposition, offering extraordinary returns. Send details to W732—Power, Chicago.

WELL-VERSED boiler-room and combustion men or established engineering agencies to sell mechanical stokers on a liberal commission basis; we manufacture three distinct types to meet all requirements; natural and forced draft. W749—Power, Chicago.

MISCELLANEOUS

ENGINEERS—Do you want to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so address Monash Engineering Co., 1417 West Jackson Blvd., Chicago, Ill.

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PATENTS. C. L. Parker, patent attorney, formerly member Examining Corps, U. S. Patent Office, McGill Bldg., Washington, D. C. Inventor's handbook sent upon request.

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